SHAI Stottler Henke Associates, Inc.
916 Holly Road
Belmont, CA 94002
(415) 595-1692
(415) 595-0358 (FAX)

March 28, 1995

Mr. Dean Carico
(NAVAIR Code RW04 BRAVO)
Naval Air Systems Command
Rotary Wing Aircraft Test Directorate
Patuxent River, MD 20670-5304

Re: Phase I Final Report, CDRL A001 - Contract N00600-94-C-2972

Enclosed please find six (6) copies of the Phase I Final Report entitled "Artificial Intelligence Techniques for Flight Test Planning". This report fulfills the requirements of CDRL A001 under Contract N00600-94-C-2972.

Also enclosed is a copy of DD Form 250 "Material Inspection and Receiving Report" for your signature upon approval of this report.

Should you have any questions, please call me at (415) 595-1692.

Sincerely,

Richard H. Stottler
Senior Partner

RHS:ms

Enclosures

cc: W. Kahle/Code 4.11F (1 copy + DD Form 1498)
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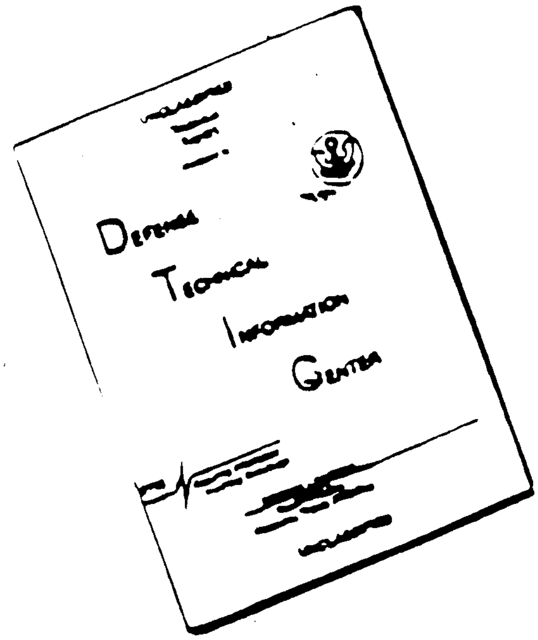

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Richard H. Stottler

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916 Holly Road
Belmont, CA 94002

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We found that several AI techniques would be applicable to the development of a system to aid flight test engineers. Flight test engineers reported that test plan and test report creation to be their most time-consuming activities and that they often made informal use of similar plans and reports. Based on the requirements of the flight test engineers, we developed the design for the Automated Flight Test Engineering System (AFTES). To prove its feasibility we implemented and demonstrated critical portions in three Phase I prototypes. AFTES is feasible and will benefit the Navy substantially when it is implemented. The three prototypes showed that the most critical aspects could be implemented. Furthermore, the very positive response we received from flight test engineers over both the AFTES designs and the Phase I prototypes indicates that AFTES will be utilized when its implemented. Finally, the fact that the productivity of flight test engineers will markedly improve is based on the fact that AFTES was designed with precisely this purpose, along with improving the quality of the plans and reports produced. For example, the test plan produced in a few minutes by the prototype can take some less-experienced flight test engineers several days to produce.

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Table of Contents

		Page
Section I: Overview		1
I.A	Introduction	1
I.B	Summary	1
I.C	Conclusions	2
Section II: Detailed Description of Results		3
II.A	Phase I Overview	3
II.B	Importance of Automating Flight Test Engineering	4
II.C	Phase I Methodologies	5
II.C.1	Case-Based Reasoning	5
II.C.2	Speech Recognition	6
II.C.3	Knowledge Engineering/Elicitation	7
II.C.4	Knowledge Representation	7
II.C.5	Knowledge Based Planning	8
II.C.6	Object Oriented Programming	8
II.C.7	Intelligent Interface	9
II.D	AFTES Description	10
II.D.1	Test Plan Development	12
II.D.2	Test Plan Execution	14
II.D.3	Data Reduction/Plotting/Presentation/Analysis	14
II.D.4	Results Reporting	15
II.D.5	Project/Competency Management	16
II.D.6	Case Bases	17
II.E	Detailed Phase I Prototype Description	19
II.E.1	Automatic Test Plan Generation	19
II.E.2	Similar Test Point Retrieval	21
II.E.3	Test Project Scheduling	22
II.F	Innovations of the AFTES Design	27
II.G	Related Systems	29
Appendix: Output of Automatic Test Plan Generation Prototype		30

Section I: Overview

I.A Introduction

Stottler Henke Associates, Inc. (SHAI) was awarded the Phase I SBIR, N94-072, Options to Improve Basic Flight Testing, to investigate ways that Artificial Intelligence techniques could be used to enhance flight test planning, data reduction, and reporting. The ultimate goal of this project was to reduce the time required to develop test plans, conduct flight testing, analyze flight test data, and produce reports.

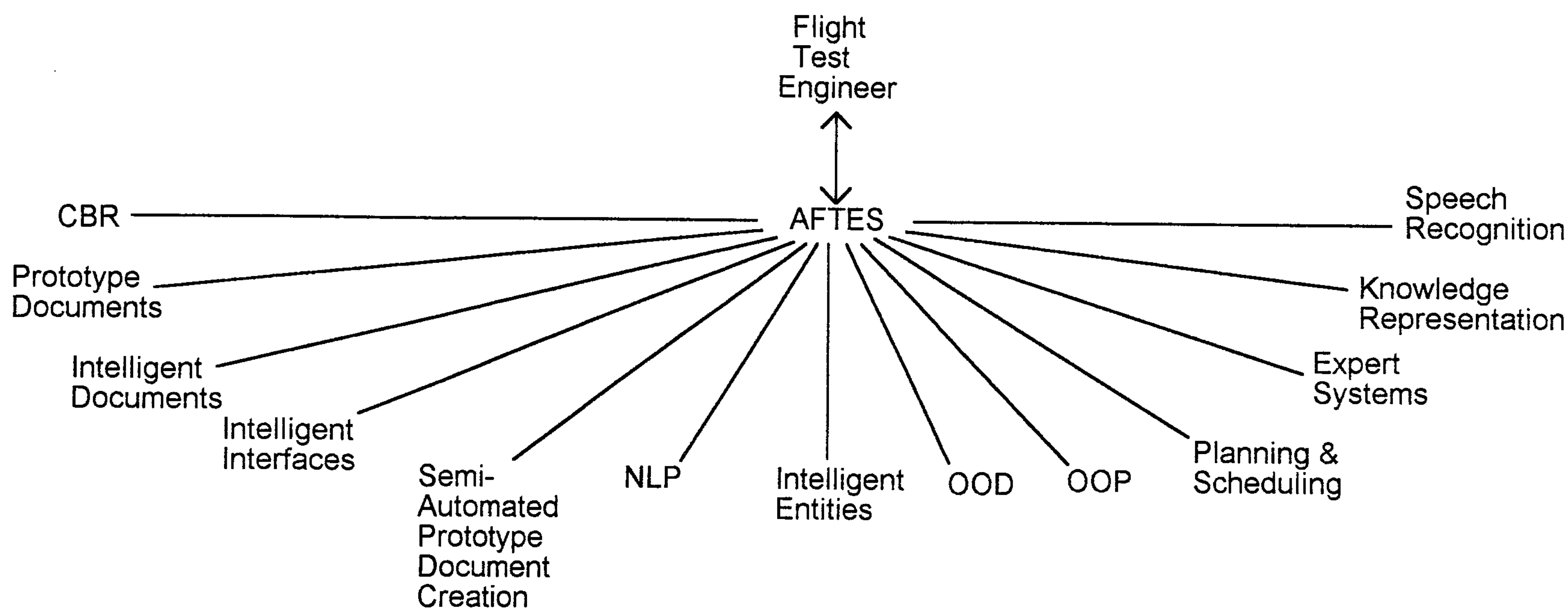
I.B Summary

We found that several AI techniques would be applicable to the development of a system to aid flight test engineers as shown in the figure on the following page. We investigated several related software tools and found that many would not be useful. FLIGHTLAB was certainly an exception in this regard. Flight test engineers reported that test plan and test report creation to be their most time-consuming activities and that they often made informal use of similar plans and reports. There were several software packages of which they made extensive use which would need to be integrated into any comprehensive software system. Based on the requirements of the flight test engineers, we developed the design for the Automated Flight Test Engineering System (AFTES). To prove its feasibility we implemented critical portions in three Phase I prototypes.

I.C Conclusions

AFTES is feasible and will benefit the Navy substantially when it is implemented. The three prototypes showed that the most critical aspects could be implemented. Furthermore, the very positive response we received from flight test engineers over both the AFTES designs and the Phase I prototypes indicates that AFTES will be utilized when it is implemented. Finally, the fact that the productivity of flight test engineers will markedly improve is based on the fact that AFTES was designed with precisely this purpose, along with improving the quality of the plans and reports produced. For example, the test plan produced in a few minutes by the prototype can take some less-experienced flight test engineers several days to produce.

AFTES
Artificial Intelligence Techniques



CBR - Case-Based Reasoning
NLP - Natural Language Processing
OOD - Object-Oriented Design
OOP - Object-Oriented Programming

Section II: Detailed Description of Results

Section II provides a complete and detailed description of the analytic results which led to the conclusions stated in Section I. Subsection A gives an overview of the Phase I effort. Subsection B describes the importance of automating flight test engineers. Subsection C describes the methodologies and AI techniques used in Phase I. Subsection D gives the design of AFTES. Subsection E describes the Phase I prototypes.

II.A Phase I Overview

The Phase I effort has been extremely successful, both in terms of proving feasibility of our ideas, and user acceptance of them. After the Phase I demonstration, we received several compliments from flight test engineers that our solution, the Automated Flight Test Engineering System (AFTES), would be usable and useful, that we had proven our ability to develop AFTES, and that the AFTES capabilities were much more on target than systems proposed by previous researchers. In fact, one group within NAWCAD PAX RIVER RW will operationally use one of the Phase I prototypes to retrieve similar test points as part of the Phase I effort.

This successful Phase I conclusion was based on a solid foundation. We performed knowledge engineering by examining dozens of documents and had several in depth discussions with flight test engineers performing a variety of types of tests throughout Rotary Wing. Through intense conversations with nine different flight engineers covering the areas of Attack Assault, Sea Control, Dynamic Interface, R&M, Flying Qualities and Performance, engine testing, simulator data acquisition, Structural testing, and Avionics, we were able to develop user requirements. From the user requirements we designed AFTES.

We surveyed existing related software tools to determine which might be useful. We found that no comprehensive tools existed to enhance NAWCAD PAX RIVER RW flight testing, but did identify a number which AFTES should interface to. We then implemented the most critical aspects of AFTES in three prototypes to absolutely prove feasibility through examples. These three prototypes were demonstrated at Pax River and were very well-received. The first prototype automatically generated DI flight test plans from information input by the user in an intelligent interface. The interface had fields which appeared or disappeared based on previous responses. The user could input which ship and helicopter would be used as well as which types of tests should be performed, definitions of the appendices, and other information needed for the test plan. The prototype then generated a complete test plan, including correct paragraph, figure, table, and appendix references (but not including the appendices themselves). The plan could then be input and edited in MicroSoft Word.

The second prototype retrieved previous DI test points similar to a target test point entered by the user. The test points had several features which were all used simultaneously. Conceptually, all fifteen to twenty thousand DI test points were simultaneously examined against all of the features of the target case and the most similar ones retrieved in a few seconds. The similarity search included concepts such as helicopters (or ships, wind speed, etc.) being different but still somewhat similar. This similarity search prototype was so well received that we agreed to spend another couple of days enhancing it, so they could use it operationally.

The third prototype showed an example of using the SHAI developed, knowledge-based, planning techniques for project and resource scheduling. About twenty flight test projects were entered and scheduled against their required resources. We showed the effect of introducing a new, high priority test project. The delays caused in other projects could be anticipated and solutions developed and tried.

II.B Importance of Automating Flight Test Engineering

The Navy is faced with the problems of aging fleet helicopters. In the current budget environment, dealing with fatigue problems and upgrading current airframes is preferable over new airframe acquisition. For NAWCAD Pax River RW, this translates into lots of flight testing for new equipment and dealing with the problems of older helicopters. New equipment may consist of new avionics, upgraded engines, or even new rotor blades. In addition, there are several different types of testing done at Pax River, including Dynamic Interface, Avionics, Reliability & Maintainability (R&M), Flying Qualities & Performance (FQ&P), Flight Control Systems, Engine, Simulator Data Acquisition, and Structural testing. As a result of both the diversity of the testing and the fact that it is primarily performed on older airframes, NAWCAD Pax River has some unique rotary wing testing requirements.

Meanwhile, the Navy is in the process of down-sizing and there is, in essence, a hiring freeze. But the testing load is increasing as the Navy tries to keep old airframes operational and up to date. There are hundreds of flight test engineers both within Rotary Wing and the more inclusive Naval Air Warfare Center Aircraft Division Pax River. The largest percentage of their time is spent writing test plans and reports. Even a modest increase in their efficiency will save the Navy enormous sums of money. Additionally, there is a need to preserve corporate knowledge before the engineers who possess that knowledge leave or retire. Once captured, that knowledge can be shared among the entire group of engineers.

The need to preserve corporate knowledge was illustrated by an actual engineering requirement during Operation Desert Storm. NAWCAD PAX RIVER RW was tasked with developing and testing equipment to retrieve airborne Unmanned Aerial Vehicles (UAVs) using a helicopter. At first this seemed to have no relation to any previous test. But one of the older engineers was able to recall that during the 1960's helicopters were sometimes used to retrieve film canisters re-entering the atmosphere and parachuting from spy satellites. The engineering and planning reports served as a starting point for the current study.

A system to automate flight testing will improve test plan development efficiency and test plan quality through improved consistency within and between plans, improved safety and identification of hazards, increased use of lessons learned from previous tests, and by allowing engineers to consider problems encountered by others. Such a system would improve the efficiency of the approval process by facilitating the use of already approved language in new plans and tracking plan changes through the approval and collaboration process. The system would improve report writing efficiency, report writing quality and consistency. It would also aid project and competency scheduling.

The need to retrieve similar data points is illustrated by a more recent example. In order to gather data for a training simulator, a helicopter's flight control system was configured unusually. The helicopter then performed some routine control response tests. Using quarter inch and half inch longitudinal stick displacements produced no unusual results. However at three quarters of an inch, the helicopter pitched so violently forward that it was actually slightly upside down. The nose angle had proceeded from 0 to more than ninety degrees. The pilot recovered and was able to make a safe landing. But a flight test engineer planning a future test involving that helicopter with similar configuration settings should retrieve and consider that extreme test point for the safety of all involved.

II.C Phase I Methodologies

While we approached flight test engineering with a number of innovative ideas and extensive experience in the field of AI and general problem solving, we did not wish to inappropriately impose a solution or methodology on the problem. Instead, we sought to first thoroughly understand the complexities of flight test planning and reporting and the needs and requirements of the flight test engineers. Using appropriate AI techniques, we then tailored a solution to the problem. The AI methodologies involved in automating flight test engineering include Case Based Reasoning (CBR), knowledge engineering techniques, knowledge representations, Intelligent Documents, Intelligent Interface, AI planning methods and object oriented programming. Each of these AI techniques is described in the following subsections.

II.C.1 Case-Based Reasoning

SHAI is a pioneer in the development and application of Case-Based Reasoning (CBR). CBR is based on the notion that people often solve problems by remembering the solution to a similar problem and adapting that solution to meet the current circumstances. CBR mimics this process. CBR is relevant to several capabilities required by flight test engineers. These include plan prototype retrieval, similar plan retrieval, similar test point retrieval, hazards and lessons learned for similar previous test projects, and similar report retrieval.

Case-based reasoning is a knowledge representation and control methodology based upon previous experiences and patterns of previous experiences. These previous experiences, or "cases" of domain-specific knowledge and action, are used in comparison with new situations or problems. These past methods of solution provide expertise for use in new situations or problems.

CBR systems offer enormous benefits compared to standard AI approaches. The knowledge elicitation bottleneck is largely circumvented. Cases can be automatically acquired directly from domain experts. Rules, on the other hand, almost always require the intervention of a knowledge engineer. Instead of having to elicit all of the knowledge required to derive a solution from scratch, only the knowledge required to represent a solution is needed.

In simple applications, a case might be represented as a database record of fields. Only the field names and types must be elicited. The data can be entered automatically. So knowledge elicitation is largely avoided with CBR and may be COMPLETELY automated depending on the type of application and the expert.

Conventional knowledge base technology dictates a single, fixed problem solving methodology. With CBR, each case, in the extreme, can represent a different methodology. Therefore, many problem solving methodologies are represented and, since new cases are continually added automatically, a CBR system's problem solving methodologies can change with time, thus improving its performance and staying up to date and relevant automatically.

Much of the research in Case-Based Reasoning is directed toward retrieving similar cases and determining what are useful definitions of similarity. It is therefore a field with great potential for use in selecting similar test plans, test points, and reports. The cases are simply previously approved plans and reports and previous data points, from which inferences and comparisons can be made using CBR.

The interactions between the different factors influencing the development of plans and reports for a given flight test are very difficult to quantify into usable rules or principles. The best way to make these evaluations is by using information from previous cases as a basis for the creation of new plans and reports. This is an ideal application for the technique of Case-Based Reasoning

The use of CBR solves the difficulty described above with appropriately combining available information to develop a plan or report. The relationships between combinations of factors will be represented appropriately in the newly created plans, because they will be based on similar cases. For example, if the type of helicopter in combination with the type of testing strongly affects the test plan, then these interactions will be represented in the test plans of similar cases.

II.C.2 Speech Recognition

Speech Recognition systems have developed to the point that they are leaving the laboratory and being fielded in applications. Currently, speech to text dictation systems exist which operate at about 60 words per minute. That is faster than most people can type but much slower than most people speak. Most of these systems are speaker dependent and operate on non-continuous speech. Speaker dependent means that the system must be trained for each individual speaker who will be using the system, which takes about one day. Non-continuous means that the speaker must pause briefly between words, which can be unnatural for some.

If the vocabulary is restricted in some way, then speaker independent, continuous speech systems can be used. This may occur when voice is used as an alternative for menu selection, for example.

Recently, researchers have reported promising results with speaker independent, continuous speech dictation systems. The research is currently moving very fast, driven by expanding use in the commercial marketplace. It is likely that by the latter half of this Phase II effort, such systems will have been validated in actual applications and available for our use.

II.C.3 Knowledge Engineering/Elicitation

Knowledge engineering is the process of eliciting and organizing information from experts in a particular domain, in our case, flight test engineering, and is the necessary precursor to development of a useful software prototype or tool. Classic AI knowledge engineering was adapted to the flight test engineering domain for this project. We have performed significant knowledge engineering in Phase I. The steps in knowledge engineering were:

1. Met with several different engineers to discuss the details of planning and reporting. The engineers included a representative sample both across the different types of flight tests and different levels of experience. We reviewed previous cases of planning and reporting flight tests, concentrating on those projects which were especially difficult, either from the uniqueness of the test or from the engineer not having enough time. This process was made easier by the fact that the plans and reports are produced in relatively standard formats but also more difficult by the fact that the process of developing a particular plan or report is not saved.

2. Observed the engineers at work. We asked the engineer to explain why he included specific tests or test conditions and why he included particular analyses in the report of test results. We asked which explanations are particular to the current project and which are more general.

3. Structured the test planning and reporting knowledge obtained. Discussed the organization of the knowledge with the engineers.

4. Once a prototype version of AFTES had been developed, presented the software to the engineers and to get their feedback on the correctness and optimality of the produced plans and reports and solicit suggestions for improvements.

II.C.4 Knowledge Representation

In order to automate the flight test planning and reporting process and allow comprehensive similar test project retrieval, one must first establish a representation in the computer of the test project and its components. These components include the elements of the test plan such as the tests, test methods, test conditions, aircraft and equipment descriptions, safety checklist, etc.; elements of the test report such as many of the same elements as the test plan, results, conclusions, deficiencies, recommendations, etc.; and the data collected including the analyses and presentation methods used.

These diverse test project components can be captured using AI knowledge representation techniques. An appropriate knowledge representation is one that naturally and completely captures desired knowledge in the domain and that can be successfully and easily manipulated to meet the needs of the application.

Test plans and reports are represented as objects with certain attributes or features, which can be used to find them in similarity retrievals. Each plan or report object includes a set of objects representing individual sections, appendices, budget, and other parts of the test plan. These individual section objects also may be individually retrieved in a similarity search, because even if the entire plan is not relevant to the current situation, an individual section might be (such as tests methods relative to a certain piece of avionics equipment). Section objects may include subsection objects or simply the text from the plan or report.

II.C.5 Knowledge Based Planning

An important aspect of many AI development efforts is the capture of the corporate knowledge of the experts. By eliciting and storing the details of a process, novices can be productive even when the experts are unavailable.

The required knowledge for flight test planning can be captured in a number of ways. First, the expert's knowledge of previous test projects is captured as a collection of cases. Second, the expert's knowledge of a very similar set of test plans and when test conditions should be included, can be captured using test condition prototypes or intelligent documents. Rules can be used to capture the inclusion criteria.

II.C.6 Object Oriented Programming

Object Oriented Programming (OOP) is a methodology for both representation and programming. Using OOP techniques, one can define different types of objects and specialized program methods that manipulate them. OOP facilitates the concept of intelligent documents in flight test planning and reporting, where the document includes the intelligence to ask users questions and tailor itself to their needs. Each object used in the plan or report process has an associated generation method and, in effect, generates itself, triggering the generation of its sub components or related references. For example, when we wish to generate an entire test plan, we would tell the test plan intelligent document object to use its generation method. This method instructs each of the test plan's constituent sections and appendices to generate themselves. Each section would then send generate messages to each of its subsections. Each subsection would send generate messages to each subsection until eventually sentences and phrases were receiving generate messages. At the lowest level a method is invoked which generates text based on user supplied answers or knowledge stored in the system, such as the maximum sideways airspeed of the test helicopter or calculating the paragraph number for a paragraph reference. The concept of intelligent entities allows complex generation algorithms to be built from very simple, particular ones.

Rules can be used more effectively throughout the generation process because they can be tailored to each object's generation method. Instead of supporting a very large rule base of general rules, we provide a large number of very small, specialized rule bases associated with each given object's generation methods. There is almost no interaction between the rule bases, because they are only related to the intelligent entity (such as a sentence) to which they are attached.

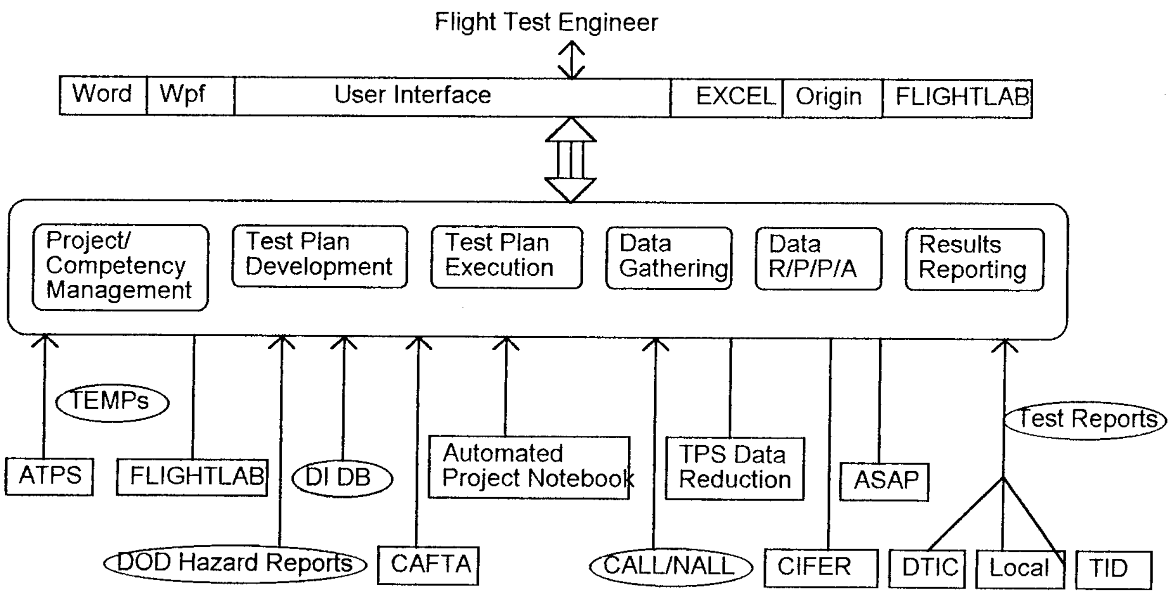
II.C.7 Intelligent Interface

An important technology to ensure user acceptance is the notion of intelligent interfaces. One example is the intelligent form. When the system requires information from the user, it is presented as fields in a form. This gives the user flexibility to fill in information in the order he wants and allows him to see a field's requested information in the context of other fields, which contrasts sharply with the more traditional expert system interface, which is a series of questions. Which fields are displayed changes dynamically, based on the answers to other questions and related knowledge the system possesses. For example, in the Phase I prototype interface, when the user entered the name of a ship, the system determined the ship's class using knowledge of the Navy's class naming conventions. Most ship classes are either RAST-equipped or not. But some classes, like FFG-61 contain both RAST and non-RAST ships. Only when the user has entered a ship in this latter class will the system display a field asking whether the particular ship is RAST-equipped.

II.D AFTES Description

Based on the results of our knowledge engineering efforts, we developed a set of requirements for a system to enhance flight testing. We then designed the Automated Flight Test Engineering System (AFTES) which addressed those requirements. AFTES is described in this section.

The Flight Test Engineer (FTE) has several different responsibilities. SHAI is striving to aid him across all of these responsibilities with one integrated system. This "one point of contact" for the FTE will necessarily therefore interface to several other tools. It will also contain diverse functionality which is divided up into six categories. They are Test Plan Development, Test Plan Execution, Data Gathering, Data Reduction/Plotting/Presentation, Results Reporting and Project/Competency Management. As shown in the following Figure 1, these six blocks make use of several external tools in addition to their own internally implemented capabilities.



Automated Flight Test Engineering System

Figure 1

The eventual AFTES will support the entire acquisition cycle as shown in Figure 2. Early in acquisition, TEMPs are developed in ATPS and passed down to AFTES for resource scheduling and flight test planning in support of developmental testing. After this phase of testing is complete, AFTES then supports the operational testing in two different ways. First, the plans, reports, and data relating to testing the aircraft during developmental testing are available to the operational testing community. These can be electronically transferred to an Operational Test Planning and Reporting System, as shown in Figure 2. Second, all of the capabilities of AFTES are available and can be applied to enhance operational flight testing. In other words the Operational Test Planning and Reporting System may be based on AFTES, itself.

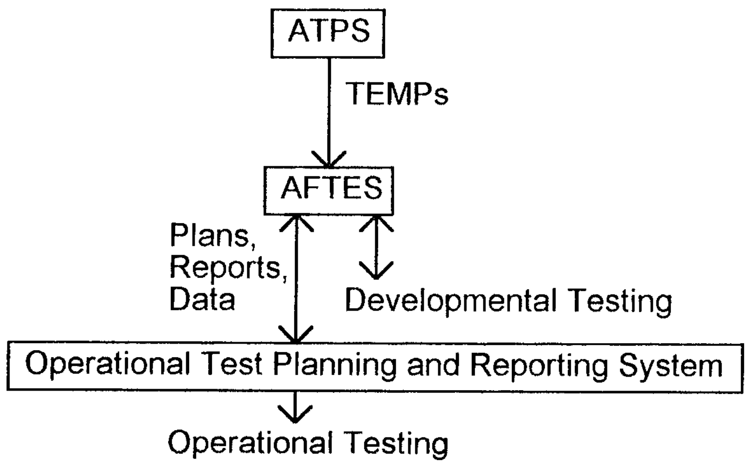


Figure 2

From our Knowledge Engineering and previous experience, we have decided that the technologies of Case-Based Reasoning (CBR), Intelligent Documents, Intelligent Interfaces, Expert System, Object Oriented Design & Programming, Planning & Scheduling, and natural language processing appear to be good solutions for much of the functionality. Most of the engineers make use of similar plans and expressed a strong desire for similarity retrieval to be much easier and comprehensive than currently available.

CBR is the field of AI dealing with the retrieval and use of past similar experiences (or cases) to solve current problems. Each case base consists of a number of cases, possibly case prototypes, one or more definitions of similarity, an index, and similarity retrieval methods as shown in Figure 3. The user can have easy access to the definitions of similarity in order to tailor the retrieval to his current desires. Similarity retrieval is generally robust without being overwhelming. Often the default similarity definition will be quite acceptable. The CBR and other AI methodologies are described in detail in Section II.C.

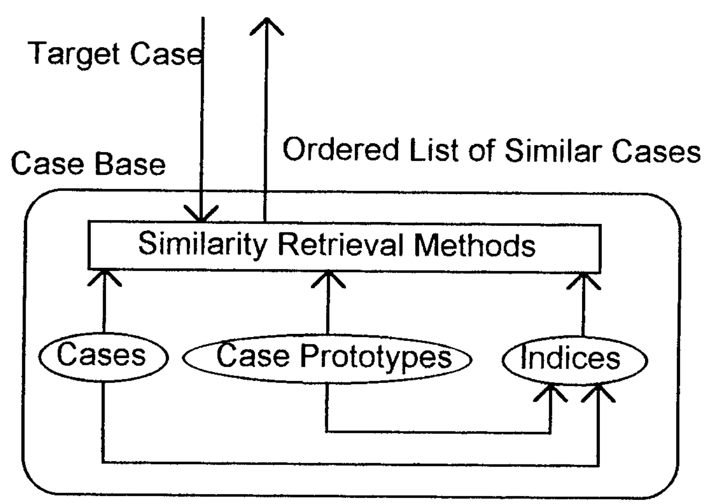


Figure 3

AFTES will run on PC compatible hardware, under Windows and on Apple Macintoshes. The user interface will be graphical, taking mouse, keyboard, and voice input. Some external tools will be incorporated into the user interface, especially word processing and data reduction tools. AFTES will interface to other engineering tools such as FLIGHTLAB, CIFER, ATPS, etc. Networking will be supported.

II.D.1 Test Plan Development

Test Plan Development includes several capabilities as shown in Figure 4. Most involve the creation of the test plan. But another capability will involve the ability to simulate or rehearse a plan, to find problems and opportunities. This will be accomplished by interfacing to ART's FLIGHTLAB. By simulating a model of the aircraft using the Tests/Test Conditions matrix, aircraft limits can be checked, data can be generated for real-time comparison to actual tests, and sensor placement checked.

The Test Plan creation process may begin by examining the current TEMP, input from ATPS. Or it may involve the input of an AIRTASK Order. Information about the helicopter and other equipment mentioned in the task order may be retrieved from the appropriate case bases. The descriptions of the aircraft and its mission and of the other equipment may be used in the test plan.

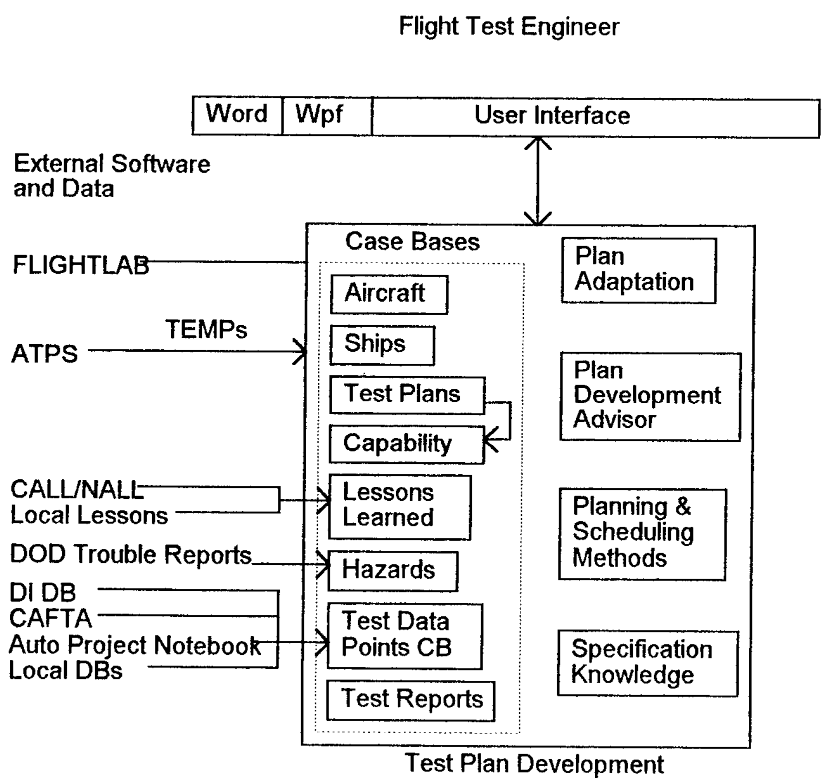


Figure 4

A large part of the plan may be able to be automatically generated at this point with the following procedure. This aircraft and other equipment information may be used to retrieve prototypical plans which will be adapted from the information used to retrieve them as well as other information elicited from the engineer. Similarity of plans in this case would be based on the type of testing, the type of aircraft and the types of other equipment, such as a ship or avionics. The near-final plan could be output into Word or WordPerfect for final editing. This is the approach used in the successful Phase I prototype.

Alternatively, for plans with no current matching prototype, similar test plans (or portions thereof) can be retrieved and used by the test engineer in a number of ways. Similarity can be based on a number of factors including similar aircraft, equipment, test objectives, test methods, hazards, etc. As little or as much information currently defined for the current test plan can be used as a target for a similarity search. Similar previous test plans can be used for many purposes. The previous plan's test methods may serve as a reminder or an inspiration, especially if innovative methods were used. The text describing the same test methods as those being used in the current plan can be copied over. The previous plan can show which test conditions are the most appropriate and the engineer can copy over tables and text describing them. Most importantly from a safety perspective, the hazards identified in the previous plans can be used as a starting point to identify hazards for the current plan. The previous plans may point out known problems with that type of aircraft or testing or identify new problems. Known areas which do not need to be tested may be described in the previous plan. The same rationale may apply to the current test. References to test standards and relevant specifications may be copied from a previous plan. Data extraction methods used in a previous plan may be appropriate for the current one. The current plan may have similar support requirements. For Example, perhaps the Operational Security section can be copied and adapted.

The engineer may also retrieve similar test points in one of two ways. He may examine the test points associated with the similar test plans already retrieved or he may retrieve similar test points from the test points case base. The test points case base will be fed from the DI Data Base, the Automated Project Notebook in Attack/Assault, CAFTA (the data base of test points and aircraft configurations used by the ITT for the V-22), and other local databases. The test points will be linked to their associated test plans, reports, and the methods executed on them for reduction, plotting, analysis, and presentation. Similar test points may be used to proceed from the known to the unknown. A prudent course for the current test may be to start with test points taken in previous similar tests. A set of similar test points from a previous test project may be verified with spot checking, thus providing more data for the current analysis. By finding out about and verifying this set of similar points, the flight test engineer can avoid duplication of effort. As indicated by the upside-down helicopter example given in Section 5.3, similar previous test points may be extremely important for finding potential problems or trouble spots.

Pax River has a diverse set of very talented groups to support all aspects of flight testing. As several flight test engineers pointed out, if you have a need for some expertise, it probably exists at Pax River. However that large, diverse set makes finding the one particular group needed difficult. A case base of engineering capability can be consulted to find the best person or group to aid the engineer with some specialized aspect of his test. This case base will be created and indexed by capabilities automatically from the authors of the test plans and reports.

Ships are a special case of equipment so the ship case base will be described explicitly. Ships will be judged similar within their class and classes will be judged similar in special circumstances such as in known air wake similarities. The ship objects will also include the ship's description, relevant equipment, and other interesting parameters.

The engineer may now have a fairly complete plan. Some plan formats may benefit from linked sections which are edited in parallel to keep them consistent. Additionally, structures engineers may require significant up front analysis before test planning is complete and AFTES would aid them.

Planning methods may be invoked to optimize the use of flight resources while obeying constraints in the gathering of required data points. Automatic scheduling could be done to resolve resource conflicts between projects. Optionally, the groupings used in similar plans can be used as a basis for grouping test conditions and maneuvers into flights. The system could then automatically generate flight cards in a tailored format.

AFTES will include knowledge of specifications, especially those specifications which are becoming more relevant and with which the engineers are currently less familiar. Examples are MIL 83300 and ADS-33.

AFTES will support the contributory test plan development process, which will become even more problematic as historically separate organizations develop combined test plans instead of separate ones. Additionally, AFTES will support the editing and approval process which occurs as test plans make their way up the chain of command. The capabilities include network access, saving an audit trail of what changes were made and who made them, and the display of the test plans with different fonts or colors to indicate different sources of changes.

II.D.2 Test Plan Execution

During text execution, similar Test Points, Plans, or Reports could be retrieved from possibly remote testing sites to help explain unexpected results. For tests run in locations with no available communication links, smaller standalone versions of these case bases can exist.

II.D.3 Data Reduction/Plotting/Presentation/Analysis

AFTES will aid the engineer in reducing and analyzing his data in a number of ways as shown in Figure 5. It could serve as a user-friendly front-end and advisor to advanced systems like CIFER. Many engineers could use a frequency analysis advisor which referenced the ADS-33 Army Specification. Another possibility is to provide advice on validating simulation models, which is often done for trainers. FLIGHTLAB may be useful here as well. Software which should be interfaced to includes:

CIFER
ASAP
RTPS
EXCEL
MatLab
MathCad
Sigma Plot
Origin
USNTPS Computer Data Reduction Routines by J. J. McCue

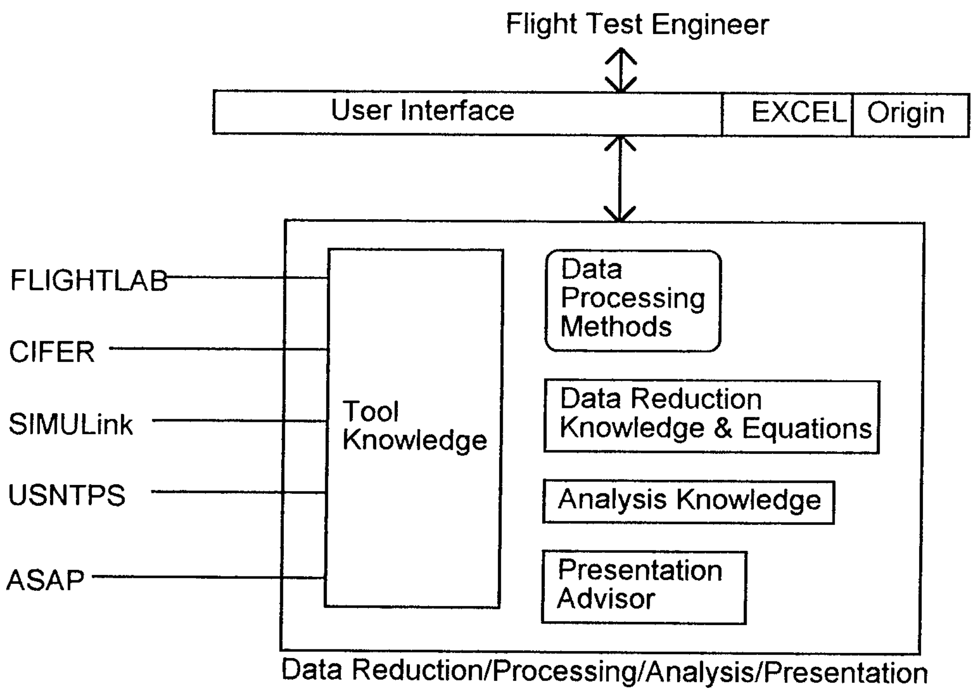


Figure 5

Data gathered is linked both to the test plan and to methods which manipulate and transform it. By storing these methods with the data, other engineers can see what data analysis steps were performed. The method information includes the software and its version, the input files, the output files, and which functions were executed.

The Analysis knowledge would include knowledge of Bode, Nichols, and Nyquist plots, for example. This knowledge could be used both as a basis for recommendation and tutorial.

II.D.4 Results Reporting

Results Reporting includes several modules as shown Figure 6. Reporting of test results must be allowed in several formats since some groups will use the standard and others will report their results through other means. In the case of a standard format, much of the report can be generated automatically and the engineer guided through the remainder with the following capabilities:

- Automatically generating each section
- Copying over text from the test plan and changing tense
- In Results and Evaluation Section, generate the first two or three sentences
- Prompt for remaining sentences
- Step user through paragraphs based on earlier sections of the test plan
- Keep paragraph number references consistent
- Keep language consistent
- Link paragraphs so they are changed in parallel
- Interface to word processing, plotting, and drawing packages

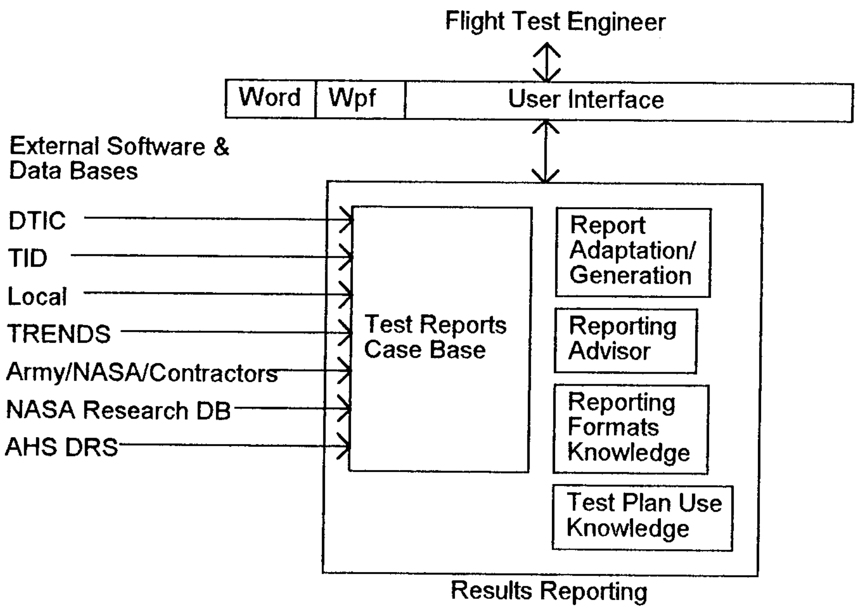


Figure 6

II.D.5 Project/Competency Management

Managing the projects and competency groups can be greatly aided by the planning and scheduling technology developed by SHAI with more than one million dollars worth of research previously funded or under contract. The NAWCAD PAX RIVER will receive the benefits of this technology for no extra cost. Project scheduling will include the scheduling of manpower and equipment resources, thus finding bottlenecks. By using information from the TEMPs and other sources, future project workload can be estimated and scheduled. In this way, potential problems can be anticipated and averted. A project manager may see that in the coming months there will be a conflict between his and a higher priority program over the instrumentation teams. This allows him to try to avoid the problem by attempting to move up his instrumentation requirements sooner.

Managers of the competency groups would benefit from the same kind of future scheduling capability. This would warn them of over or under utilization problems coming down the road and to take appropriate action such as hiring more engineers or finding other competencies for temporary assignment of his engineers. The Competencies would also benefit from a tutorial component. Previous test plans can be examined and performed again in simulation. The simulation models can also be used to give the student better qualitative and quantitative feel for the helicopter performance.

II.D.6 Case Bases

Several Case Bases have been referred to in the above sections. They are briefly described here.

Projects Case Base

- Projects include: Test Plans, Data, Data Processing Methods, Reports
- Link: Test plan - Data gathered - Data Processed - Final report
- Keep track of how data was processed (i.e. excel spreadsheet) so the processing could be duplicated
- Saving the process
- Retrieved test plan is more valuable if user can see the results
- Links between projects, some projects are precursors to others

Test Plan Case Base

- Cases originate from within sections
- Test Plan Similarity
    - Equipment, its function/mission
    - Aircraft, its mission
    - different similarity definitions for different areas
- Includes:
    - Test/Test Conditions
    - Sections
    - Hazards
    - AIRTASK
    - Specs Referenced/Compared to

- Test Plans retrieved in whole or part

Results Reports Case Base

- Cases originate from TID, DTIC, and from within groups
- Similarity Retrieval

Aircraft Case Base

Aircraft Descriptions/Illustrations for inclusion in plans and reports
Features
Similarity between Aircraft types predefined.
Mission descriptions for each
Suggested representative tasks and tests which are used to evaluate the aircraft's ability to do them
Envelopes with rationale

Lessons Learned Case Base

Cases originate from CALL/NALL and within each group.

Hazards Case Base

- Cases originate from test plans and DOD problem reports
- Automated Case-Base analysis to suggest common ones for different types of tests or aircraft
- Historic problems from formal R&M database and Cherry Point

II.E Detailed Phase I Prototype Description

The Phase I effort included development of three prototypes - Automatic Test Plan Generation, Similar Test Point Retrieval, and Test Project Scheduling.

II.E.1 Automatic Test Plan Generation

The first prototype automatically generated DI flight test plans from information input by the user in an intelligent interface Shown in Figures 7 through 9. The interface had fields which appeared or disappeared based on previous responses. For example, in Figure 7, RAST-Equipped only appears if a ship's name is entered which corresponds to a class of ships, some of which are RAST-equipped and some of which are not. Likewise, which kind of lighting evaluation will be done is only requested if the user inputs that a lighting evaluation will be done at all. The user could input which ship and helicopter would be used as well as which types of tests should be performed, definitions of the appendices, and other information needed for the test plan. The prototype then generated a complete test plan, including correct paragraph, figure, table, and appendix references (but not including the appendices themselves). The plan could then be input and edited in MicroSoft Word. The Test plan generated from the input from the following screens is given in the Appendix.

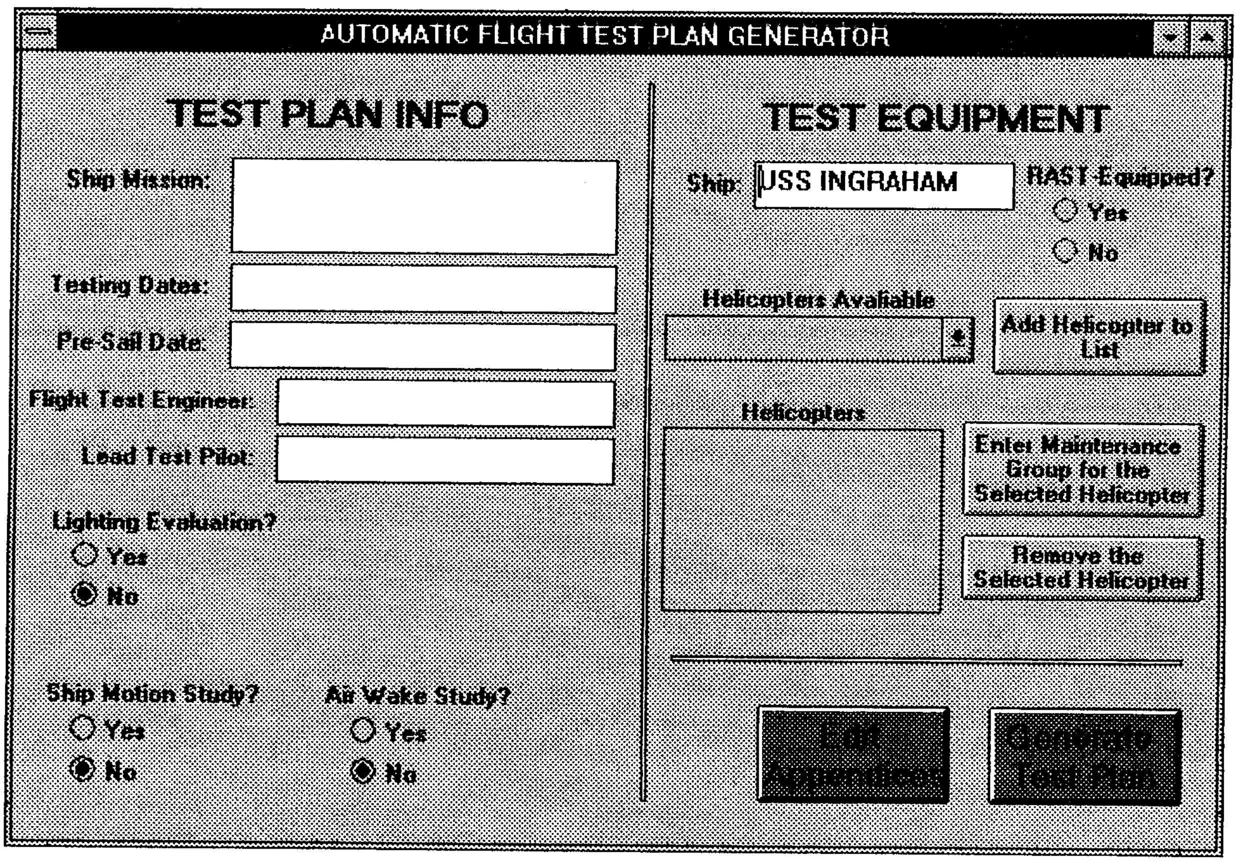


Figure 7

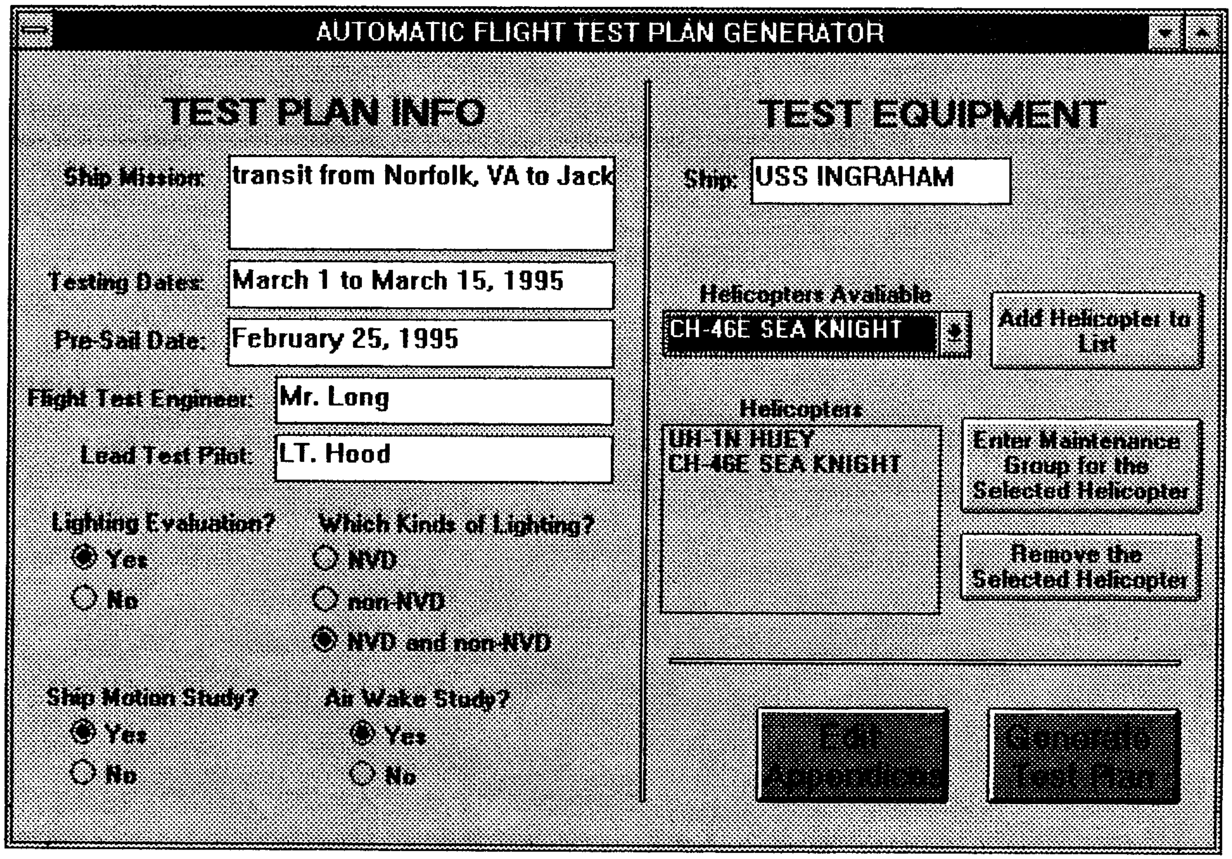


Figure 8

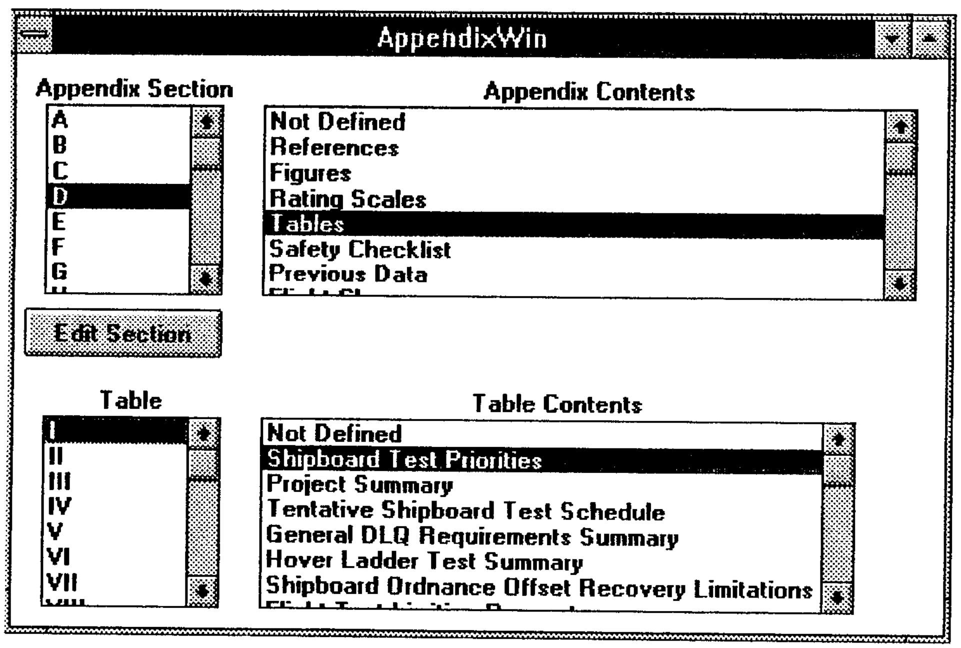


Figure 9

The Automatic Test Plan Generation prototype was developed by scanning a test plan into electronic form and parsing it into sections, subsections, and sentences, based partly on the table of contents. The sentences were then parsed to identify ones change for different plans, such as helicopter names, or paragraph or figure references. These were then exchanged for intelligent objects which could generate the appropriate text based on user responses or other calculations.

II.E.2 Similar Test Point Retrieval

The second prototype retrieved previous DI test points similar to a target test point entered by the user. The test points had several features (as shown in Table 1) which were all used simultaneously. Conceptually, all fifteen to twenty thousand DI test points were simultaneously examined against all of the features of the target case and the most similar ones retrieved in a few seconds. Table 2 shows the output from the similarity retrieval which corresponds to the input of Table 1. The most similar retrieved data point is shown in Table 3. The similarity search included concepts such as helicopters (or ships, wind speed, etc.) being different but still somewhat similar. This similarity search prototype was so well received that we agreed to spend another couple of days enhancing it, so they could use it operationally.

Ship: AGF-5
Landing Spot: 1
Helicopter: AH-1W
Wind Speed: 30
Wind Direction: 90
Approach: P
Pitch: 4
Roll: 8
WMO Sea State: 4
Visibility: 4

Target Test Point Input
Table 1

Score	Helicopter	Ship-Hull-Spot	W.Dir	W.Speed
Target	AH-1W	AGF-3-1	90	30
56 %	AH-1T	LPD-4-1	85	30
56 %	AH-1W	LHD-1-8	95	35
55 %	AH-1W	LHD-1-1	80	30
54 %	AH-1W	LHD-1-8	95	30
54 %	AH-1W	LHD-1-1	100	30

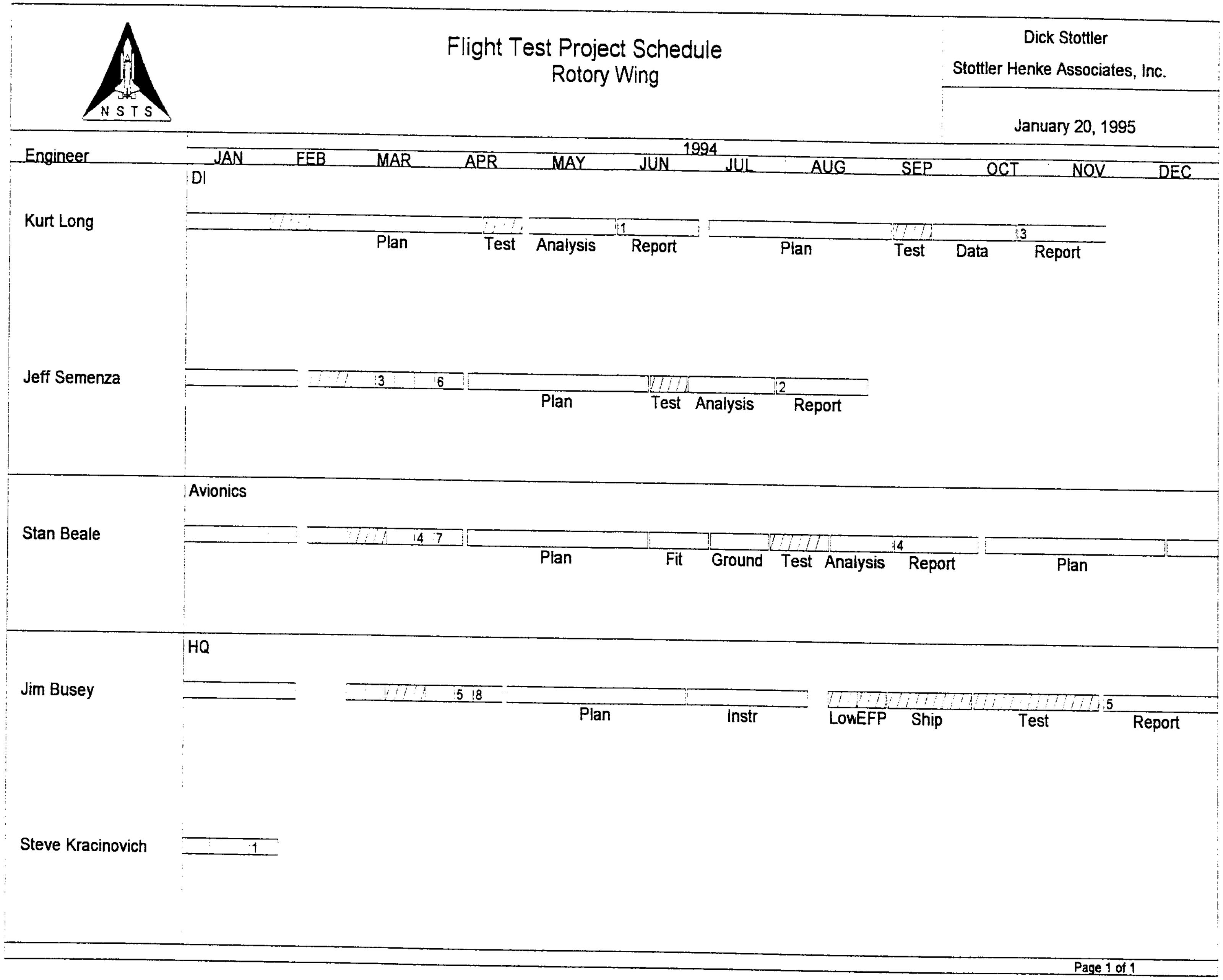
Similarity Retrieval Output
Table 2

Landing: 1 = 56%
Helicopter = AH-1T
Ship = LPD-4
Landing Spot = 1
Hull Number = 4
Wind Speed = 30
Wind Direction = 85
Approach = P
Pitch = 5
Roll = 9
WMO Sea State = 2
Visibility = 1
Time = 3:0
Longitude = 159
Latitude = 67
ACCG = 145
ACGW = 10747
Take Off PRS = 3
Recovery PRS = 4
Desired LU = 0
Actual LU = 8

Most Similar Retrieved Point
Table 3

II.E.3 Test Project Scheduling

The third prototype showed an example of using the SHAI developed, knowledge-based, planning techniques for project and resource scheduling. About twenty flight test projects were entered and automatically scheduled against their required resources. The resulting schedule is shown in Figures 10 and 11. We then introduced a new, high priority test project and automatically rescheduled. The resulting schedule is shown in Figures 12 and 13, and reflects the effects of the high priority project grabbing resources from the other projects. The resulting delays caused in these other projects could be anticipated and solutions developed and tried.


NSTS
Flight Test Project Schedule
Rotory Wing
Dick Stottler
Stottler Henke Associates, Inc.
January 20, 1995
Engineer
1994
JAN
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Kurt Long
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Test
Analysis
Report
Plan
Test
Data
Report
Jeff Semenza
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2
Plan
Test
Analysis
Report
Avionics
Stan Beale
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Jim Busey
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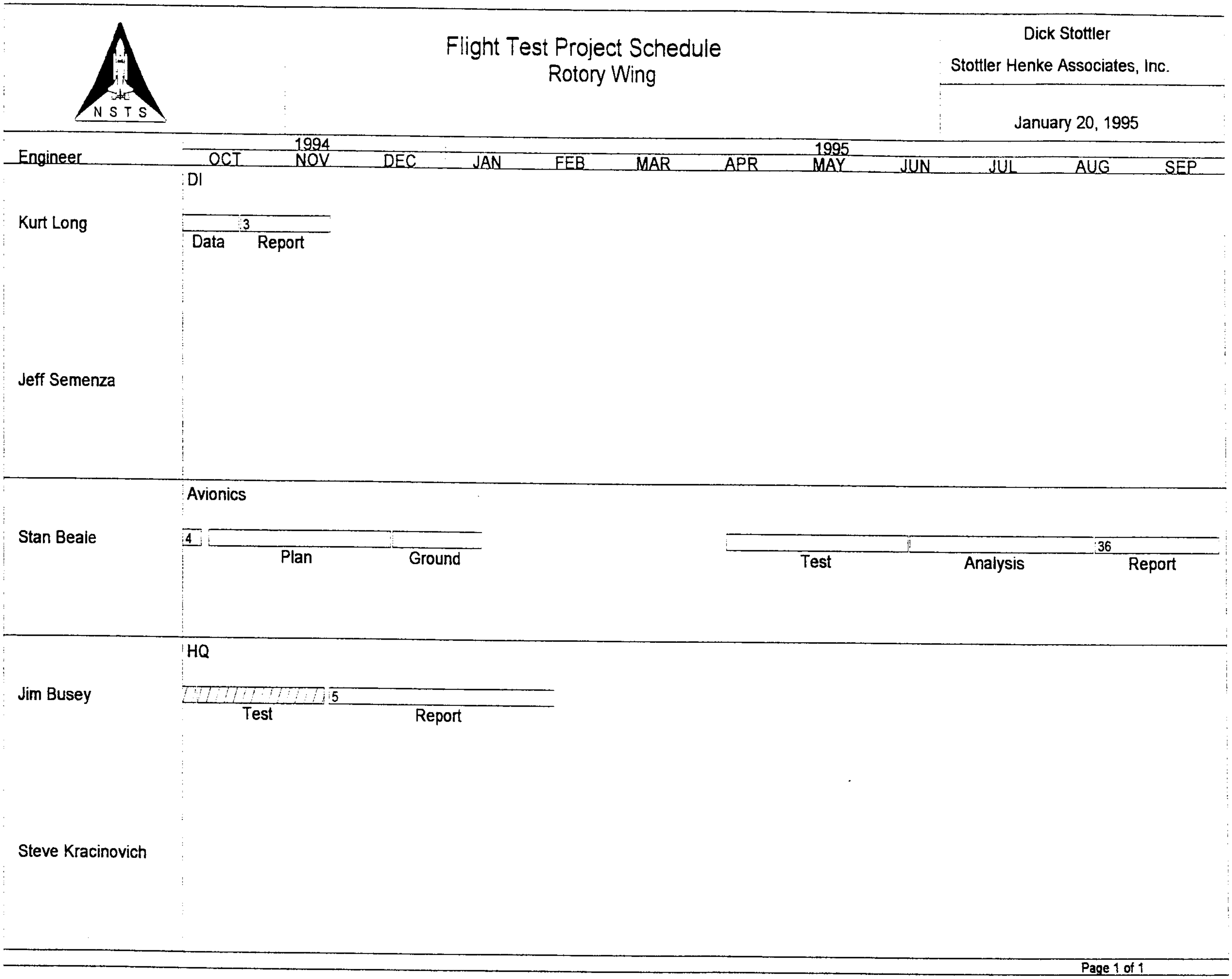
LowEFP
Ship
Test
Report
Steve Kracinovich
1
Page 1 of 1

Figure 10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Data
Report
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Avionics
Stan Beale
4
Plan
Ground
Test
Analysis
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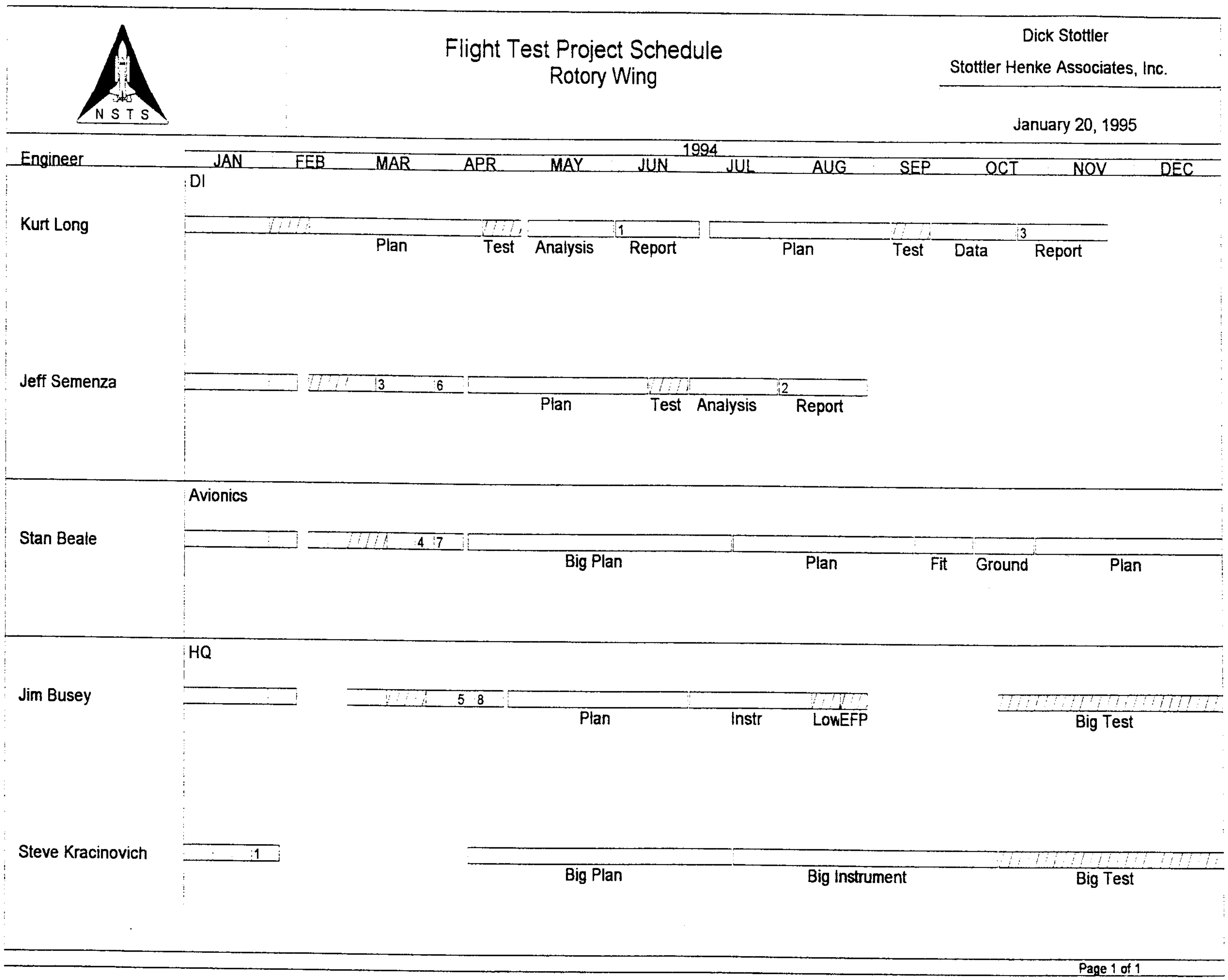
Report
HQ
Jim Busey
5
Test
Report
Steve Kracinovich
Page 1 of 1

Figure 11



Flight Test Project Schedule
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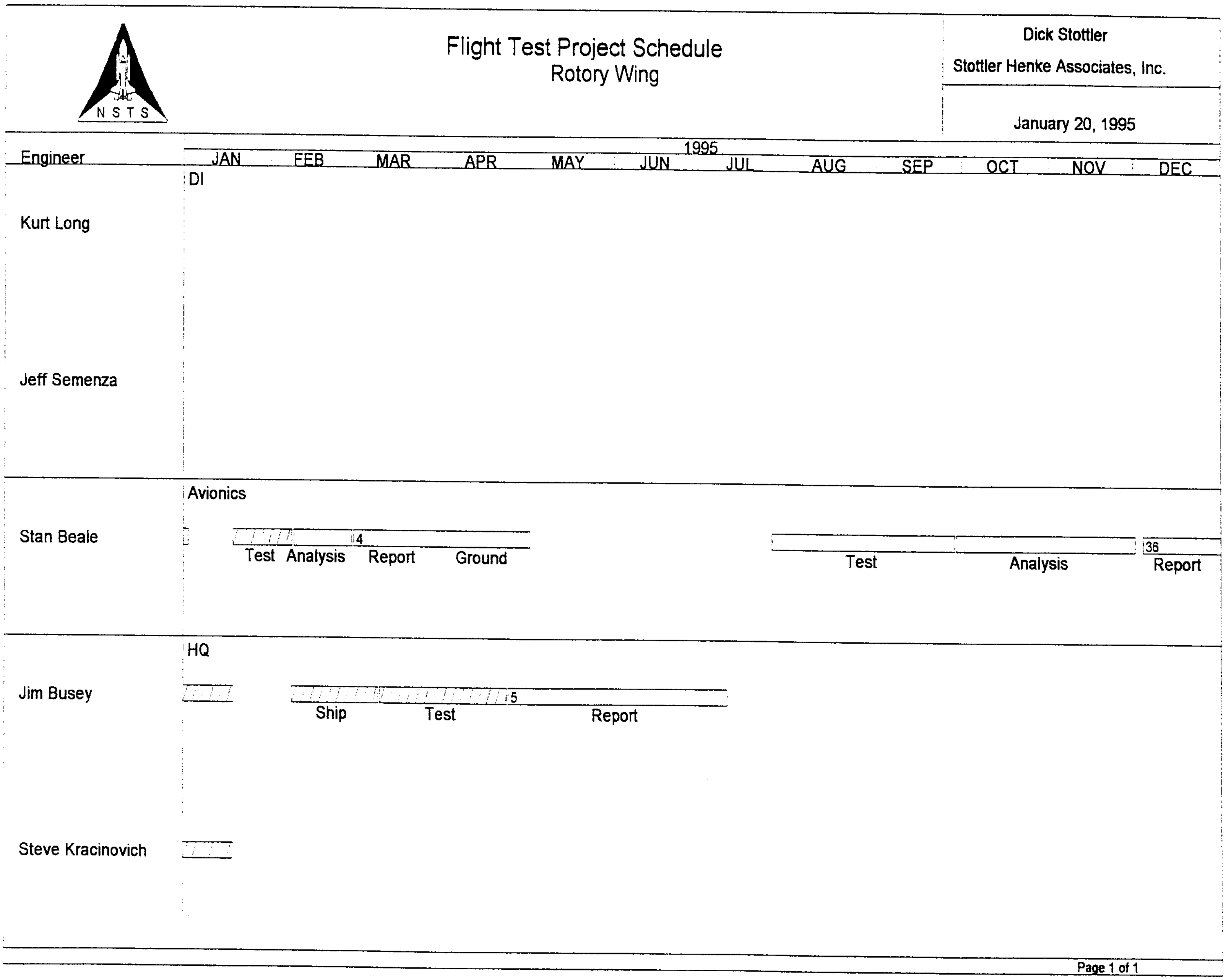
DI
Kurt Long
Plan Test Analysis 1 Report Plan Test Data 3 Report
Jeff Semenza
3 6 Plan Test Analysis 2 Report
Avionics
Stan Beale
4 7 Big Plan Plan Fit Ground Plan
HQ
Jim Busey
5 8 Plan Instr LowEFP Big Test
Steve Kracinovich
1 Big Plan Big Instrument Big Test
Page 1 of 1

Figure12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HQ
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Test
Report
Steve Kracinovich
Page 1 of 1

Figure 13

II.F Innovations of the AFTES Design

There are several aspects of AFTES development which are especially innovative. They are described below.

1. Comprehensive, Integrated Treatment of Flight Test Engineering

In developing the AFTES design, SHAI investigated all aspects of flight test engineering, not just one narrow focus. We investigated several flight test engineering tasks and several types of flight testing, to design a comprehensive, integrated system which would aid the engineer across all of his tasks and across several testing domains.

2. Use of Several AI Techniques in Combination

SHAI prides itself in knowledge of a diverse set of Artificial Intelligence solution techniques. With this knowledge, we examined the various aspects of the flight testing process and developed a solution which addresses each task with the technology most suited. The AFTES solution, therefore, includes several different techniques. These include Case Based Reasoning (CBR) , natural language processing, Object-Oriented Design and Programming, Intelligent Documents, Intelligent Interfaces, Knowledge Representation, conventional expert system technology, and speech recognition.

3. Case Based Reasoning

Case Based Reasoning (CBR) has not been applied to flight testing before. CBR systems can adapt by learning new or innovative methods, simply through the addition of more cases (test plans and reports). These cases will include sub cases which can be retrieved corresponding to sections of the plans and reports. CBR will formalize the current informal practice of using similar plans and reports. By capturing test projects, these projects are preserved and can be shared among all users, when appropriate. Similarity retrieval will be supported for similar test plans, test reports, and test points. This capability replaces the more unwieldy use of Boolean or relational data base queries. Instead of specifying the desired data with logical clauses connected with Ands and Ors, the user specifies his current situation, and similar items are retrieved. He can easily change the relative importance of various features. This type of retrieval is much more natural since it more closely approximates the functioning of human memory. A final benefit of CBR technology is that the captured cases can be used as a basis for tutoring.

4. Automatic Test Plan and Test Report Generation

Often, most of a test plan or test report can be automatically generated from a prototype plan or report. A single prototype represents a set of plans and reports by listing which parts they have in common and describing the differences along with conditions on when those different parts are applicable. Using the conditions and user input, the plan or report is generated and output in word processing form for final editing by the user. We successfully demonstrated this capability for Dynamic Interface test plans in Phase I.

5. Intelligent Documents

An object-oriented design technique is to group procedural code along with the data on which the code operates together into objects. This can be taken one step further by representing with the object, all of the knowledge required to manipulate the object, leading to the concept of intelligent entities. One specialization of the intelligent entity concept is intelligent documents, where a document includes all of the knowledge required to ask the user for input and tailor itself to the user's current requirements.

6. Intelligent Interfaces

An intelligent interface, alters the set of required input from the user based on previous user inputs. In expert systems, this was traditionally done in a question and answer (consultation) format, where a user answered questions which were presented to him one at a time. A more user-oriented approach is to supply a dynamic form, whose fields change as the user provides input to other ones. In this way, the user can select the order of input and sees one field in the context of the others.

7. Semi-Automated Document Prototype Creation

In Phase I, SHAI demonstrated the feasibility of generating a prototype test plan from an actual one. The test plan was scanned into electronic form, parsed into sections, subsections, and sentences, based partly on the table of contents. The sentences were then parsed to identify ones which change for different plans, such as helicopter names, or paragraph or figure references. These were then exchanged for intelligent objects which could generate the appropriate text based on user responses or other calculations. This process will also be applied for the creation of test report prototypes.

8. Test Plan Rehearsal

By driving the FLIGHTLAB helicopter simulation with the test condition matrix, a test plan can be rehearsed and possible problems found, such as dangerous test conditions or suboptimal sensor placement. Additionally, data can be generated for real-time comparison, leading to increased safety.

9. Intelligent Entity Planning

The automated techniques SHAI has and is developing for knowledge-based planning, funded for over one million dollars by other clients, will be applied to project and resource scheduling in this project at no extra cost to the Navy.

II.G Related Systems

Related systems have been developed by others. FLIGHTLAB is currently under development by Advanced Rotorcraft Technology (ART) located near SHAI. FLIGHTLAB is a comprehensive, flexible, high-fidelity, advanced aerodynamic simulation capability which supports the full life-cycle of weapon system acquisition from design thorough testing and equipment updates. SHAI will work closely with ART to supply AFTES users with an interface to FLIGHTLAB. SAIC (Science Applications International Corporation) has developed the Automated Test Planning System (ATPS) for the development of TEMPs (Test & Evaluation Master Plans). AFTES will be able to read these TEMPs electronically.

Test PAES (Test Planning Automation and Evaluation System) was originally developed for human factors testing at Wright Patterson AFB, but has been expanded to include others. TEST PLAN was developed by G&C Software for fighter planes. It has recently been applied to new fixed wing passenger and transport aircraft. These systems do not really address any issues faced by Pax River flight test engineers.

TPAS (Test Planning Automation System) was a prototype developed at Pax River by John McMaster. It much more closely addresses Pax River's needs than the other systems, especially in that it generated the text of a test plan. Unfortunately, funding was never available to move it beyond the prototype stage.

Appendix: Output of Automatic Test Plan Generation Prototype

TABLE OF CONTENTS

BACKGROUND
PURPOSE
DESCRIPTION OF TEST EQUIPMENT
- UH-1N HUEY
- CH-46E SEA KNIGHT
- USS INGRAHAM (FFG 61)
- ELEVATED FIXED PLATFORM (EFP)
- NVD COMPATIBLE SHIPBOARD LIGHTING

SCOPE OF TESTS
- TESTS AND TEST CONDITIONS
- TEST LOADINGS
- TEST ENVELOPES
- TEST CONFIGURATIONS
- DATA COLLECTION

METHOD OF TESTS
- LANDBASED FLIGHTS
- SHIPBOARD FLIGHT TESTS
- SHIPBOARD NON-FLIGHT TESTS
- INSTRUMENTATION

SUPPORT REQUIREMENTS
SPECIAL PRECAUTIONS
MANAGEMENT
- FUNDING REQUIREMENTS
- SCHEDULE/MILESTONES
- PERSONNEL ASSIGNMENT
- PROJECT SECURITY
- REPORTS
- PROJECT DOCUMENTATION
- ENVIRONMENTAL IMPACT

LIST OF APPENDICES

BACKGROUND

1. Reference (a) tasked NAVAIRWARCENACDIV Patuxent River MD (NAWCAD Pax River) to conduct dynamic interface (DI) testing of various helicopter/ship combinations, in order to improve all aspects of shipboard helicopter compatibility, and to develop shipboard operational launch/recovery envelopes. References (b) and (c) reported the fleet need for development of UH-1N and CH-46E launch/recovery operational envelopes aboard Recovery Assist, Secure Traverse (RAST)-equipped FFG 7 class ships. References (d) through (m) discussed the availability of ship, helicopter, and maintenance assets in support of UH-1N and CH-46E shipboard high sea state DI

launch/recovery envelope development tests conducted aboard USS INGRAHAM (FFG 61) in March 1 to March 15, 1995.

2. Reference (n) tasked NAWCAD Pax River to conduct flight test and evaluation efforts in order to develop shipboard lighting and marking configurations that are compatible with rotorcraft Night Vision Device (NVD) operations aboard various air-capable surface combatant ships. References (o) and (p) reported results of shipboard H-60/flight deck lighting NVD compatibility evaluations conducted under this tasking, and recommended the conduct of additional shipboard flight test operations to further validate the concept. Reference (q) confirmed the desirability of conducting a night NVD and non-NVD shipboard lighting compatibility evaluation concurrently with previously scheduled UH-1N and CH-46E test operations in early 1994.

3. As discussed in references (h) through (r), in support of the test efforts described in paragraphs 1 through 3, at-sea UH-1N and CH-46E DI tests will be conducted aboard USS INGRAHAM (FFG 61) between March 1 to March 15, 1995, during transit from Norfolk, VA to Jacksonville, FL.

PURPOSE

4. The primary purpose of this evaluation to develop UH-1N and CH-46E day/night (NVD and non-NVD) nondegraded Automatic Flight Controls System (AFCS) shipboard launch/recovery envelopes aboard RAST-equipped FFG 7 class ships. Secondary purposes include:

a. NVD and non-NVD evaluation of the compatibility characteristics of a prototype NVD-compatible flight deck, Helicopter Control Station (HCS), and LSO (Landing Safety Officer) station lighting configuration for use by various aircraft aboard FFG 7 class ships.

b. Documentation of RAST-equipped FFG 7 class ship motion characteristics.

DESCRIPTION OF TEST EQUIPMENT

UH-1N HUEY

5. The UH-1N is a utility transport helicopter manufactured by Bell Helicopter Textron for the United States Marine Corps. The aircraft's maximum gross weight is 10,500 lb. UH-1N airspeed limits are 80 KIAS for forward flight, 30 KTAS for sideward flight, and 10 KTAS for rearward flight. A detailed description of the UH-1N is found in reference (s); a drawing of the aircraft is presented in appendix B, figure 1. An RWATD UH-1N will be used for landbased buildup evolutions, and an embarked fleet UH-1N will be used for all shipboard evolutions. The shipboard test aircraft and maintenance support will be provided by an embarked UH-1N detachment from Marine Light Attack Helicopter Squadron (HMLA), from MCAS Camp Pendleton, CA. The UH-1N test aircraft will be capable of shipboard NVD operations, and if possible, will carry internal auxiliary fuel tanks. If possible, the UH-1N will be equipped with a

stab bar (vice a SCAS-equipped aircraft) to test worst case handling qualities. Both UH-1Ns will be representative of production UH-1N aircraft for test purposes.

CH-46E SEA KNIGHT

6. The CH-46E is a tandem rotor assault transport helicopter manufactured by the Boeing Vertol (now Boeing Helicopter) Company for the United Stated Marine Corps. The aircraft's maximum gross weight (internal and/or external cargo) is 24,300 lb. CH-46E airspeed limits are 145 KIAS for forward flight, 35 KTAS for sideward flight, and 30 KTAS for rearward flight. A detailed description of the CH-46E is found in reference (s); a drawing of the aircraft is presented in appendix B, figure 1. An RWATD CH-46E will be used for landbased buildup evolutions, and an embarked fleet CH-46E will be used for all shipboard evolutions. The shipboard test aircraft and maintenance support will be provided by an embarked CH-46E detachment from Marine Medium Helicopter Squadron (HMM), from MCAS Tustin, CA. The UH-1N test aircraft will be capable of shipboard NVD operations, and if possible, will carry internal auxiliary fuel tanks. Both CH-46Es will be representative of production CH-46E aircraft for test purposes.

USS INGRAHAM (FFG 61)

7. USS INGRAHAM (FFG 61) is the fifty-first and last (commissioned 5 August 1989) ship of the Oliver Hazard Perry (FFG 7) class of guided missile fast frigates. Built by Todd Shipyards, San Pedro, CA, USS INGRAHAM, like each ship in the FFG 7 class, is 453 ft long, 45 ft wide, has a 25 ft draft, and displaces approximately 4100 tons fully loaded. Two General Electric LM-2500 marine gas turbine engines, producing a total of approximately 41,000 shp, propel each FFG 7 class ship via a single, constant pitch screw to speeds in excess of 30 kt. Each FFG 7 class ship has a single rudder and fin stabilizers to improve roll stability (usually at the expense of an increased vertical or heave, motion). Each ship in the FFG 7 class has a single helicopter operations platform, which is located immediately aft of twin hangars (each capable of holding a folded H-60 or equivalent sized aircraft) and approximately 16 ft above the ship's waterline. On all FFG 7 class ships completed after FFG 36 (including USS INGRAHAM), and also as a retrofit to several earlier ships, the aft portion of the flight deck has been lengthened and two complete (one to port, and one to starboard) RAST systems have been installed, permitting H-60 (or suitably-equipped derivative) operations in adverse ship motion conditions. An aviation facilities summary and flight deck drawing for USS INGRAHAM is presented in appendix B, figure 3. Reference (u) provides the most recent aviation facilities certification for USS INGRAHAM. A description of the standard RAST-equipped FFG 7 class Visual Landing Aids (VLA) lighting package (installed aboard USS INGRAHAM) is presented in appendix I, table I.

ELEVATED FIXED PLATFORM (EFP)

8. The Elevated Fixed Platform (EFP) Facility, located at Naval Air Warfare Center, Lakehurst, NJ (NAWCAD Lakehurst), is a reconfigurable fixed platform that currently simulates an FFG 7 class ship flight deck and aft hangar face. It includes operational FFG 7 class Visual Landing Aids (VLA), including deck and hangar face lighting. The EFP maintains an operable LSO Station (moved laterally outboard from its actual shipboard location for safety reasons), and

fully functional RAST hauldown, securing, and traversing equipment, thereby producing a realistic land-based RAST system virtually identical to that of a RAST-equipped ship. The EFP does not move, and thus cannot duplicate wind or ship motion conditions typical of ships, but otherwise, exhibits excellent fidelity for use in pilot/LSO training, proficiency, and/or other limited scope evaluation. NAWCAD Pax River has used the EFP for over 10 prior H-60 DI buildup evolutions within the last 3 years. During pilot buildup evolutions conducted as part of this test, the EFP will be configured with the same NVD compatible lighting configuration that will be employed during this at-sea test. Appendix H contains drawings and photographs of the EFP.

NVD COMPATIBLE SHIPBOARD LIGHTING

9. As discussed in references (o) and (p), typical RAST-equipped DD 963, CG 47, or FFG 7 class shipboard flight deck VLA lighting configurations are not compatible with NVD helicopter operations. However, as discussed in references (o) and (p), the NVD compatibility characteristics of a modified flight deck VLA lighting configuration were evaluated aboard USS RENTZ (FFG 46) and aboard USS ARTHUR W. RADFORD (DD 968) in 1992 and 1993. This VLA lighting configuration, described in appendix I, table II, consists of blue filters installed in the overhead floodlights and blue filters and cool beam lamp units installed in the hangar face and deck surface floodlight (dustpan) units. Based on FFG 46 and DD 968 DI test results provided in references (o) and (p), additional ship's interior lighting NVD compatibility is provided by the addition of several Electro-luminescent (EL) panels mounted in both HCS and LSO stations. This shipboard lighting configuration (which previously has demonstrated the capability to provide ample flight deck and aircraft illumination, suitable for use by both non-NVD equipped shipboard personnel and by NVD or unaided aircrews conducting operations to such decks) will be evaluated throughout all night tests described in this document.

SCOPE OF TESTS

TESTS AND TEST CONDITIONS

10. A summary of landbased and shipboard test priorities is presented in appendix D, table I. To successfully complete the desired test objectives, the evaluations described in appendix D, table II will be conducted aboard USS INGRAHAM (FFG 61) during transit from Norfolk, VA to Jacksonville, FL on March 1 to March 15, 1995. At-sea UH-1N and CH-46E testing will include both day and night test periods: approximately six day and six night shipboard flight test periods (of approximately 3-4 hours duration each, producing a total of approximately 40 shipboard flight test hours) are scheduled. Tentative plans include the use of embarked fleet aircraft and maintenance support for all shipboard flight test operations.

11. In accordance with appendix D, table I through III, shipboard operations will primarily consist of at-sea day and night (NVD and non-NVD) UH-1N and CH-46E launch/recovery evolutions. The tentative plan depicted in appendix D, tables I through III is designed to facilitate the concurrent accomplishment of all test objectives aboard up to three different ships during up to three different underway periods. Additional or alternative test periods will be scheduled as available; the number and duration of test periods, as well as the daily flight schedule, will be

modified as necessary after the start of testing, dependent on weather, scheduling, test completion, crew rest, or other emergent requirements.

TEST LOADINGS

12. All test flights will be conducted within gross weight and CG limits defined in the appropriate NATOPS and NWP 42 (Shipboard Helicopter Operational Procedures) manuals (references (s), (t), and (x), respectively). During shipboard flight operations, the aircraft will be refueled aboard ship approximately every two hours as necessary to achieve the desired loadings specified in appendix D, table II.

TEST ENVELOPES

13. Test flights will be conducted within limitations described in the appropriate aircraft NATOPS Flight Manuals (references (s) and (t)), Shipboard Helicopter Operational Procedures Manual (NWP 42 Rev J. reference (x)), CNSP NVD SOP (reference (x), and RWATD SOP (reference (y)), except as authorized by the DI general flight clearance (reference (z)), and the ship's blue lighting flight test aviation facilities certification (reference (aa)). Testing will not be conducted under any conditions without appropriate clearance/authorization from all required commands.

TEST CONFIGURATIONS

14. Descriptions of desired aircraft test configurations are presented in appendix D, table II. As discussed in appendix D, table II, the UH-1N and CH-46E will carry no external stores. The UH-1N and CH-46E will carry internal auxiliary fuel tanks to boost its average gross weight. Presuming that appropriate NVD operating clearances are obtained from CNSP, all aircraft will conduct NVD operations.

DATA COLLECTION

15. Pilots and/or aircrew will employ portable audiocassette tape recorders to record comments (via the aircraft Internal Communications System (ICS)) during day and night operations.

16. Pilots will monitor and record aircraft performance parameters on kneeboard data cards during daylight flight test sequences only. Sample pilot kneeboard data card forms are presented in appendix B, figures 6 and 7.

17. The Shipboard Test Coordinator (located either in the LSO station, in HCS, or on the bridge), will be in radio contact with the pilots during testing, and will coordinate general test progression, ensuring that the appropriate evolutions are conducted in accordance with this document.

18. The Bridge Coordinator will ensure that ambient atmospheric conditions, including true wind, ship course/speed, weather and sea state parameters are recorded during each launch/ recovery sequence. Additionally, he will calculate and relay desired relative wind and ship course/speed parameters to appropriate ship personnel during testing. A Bridge Coordinator data sheet is presented in appendix B, figure 8.

19. The Aircraft Project Engineer, located in HCS or the LSO station, will be in radio contact with the pilots during testing, and will record test conditions (including lighting intensity settings at night) and pilot post-event comments. A sample Aircraft Project Engineer data sheet is presented in appendix B, figure 9.

20. The Ship Motion Instrumentation Engineer, located either on the bridge, in Combat Information Center (CIC), or at some other desirable position (determined before the installation of the DI ship motion package), will operate the DI ship motion package during all launch/ recovery sequences. A sample Ship Motion Instrumentation Engineer data sheet is presented in appendix B, figure 10.

21. The Audio Visual Instrumentation Coordinator, located on the flight deck, on the hangar roof, or at other advantageous locations, will coordinate the operation of DAVIS (described in paragraph 56b), and will ensure that portable VHS format video camcorders and 35mm still cameras are employed to provide both day and night documentation of the video/photo documentation objectives presented in appendix B, figure 11.

METHOD OF TESTS

LANDBASED FLIGHTS

PROFICIENCY FLIGHTS

22. In order to ensure maximum pilot proficiency, each project pilot will conduct preparatory flights prior to the conduct of DI shipboard test evolutions. These flights, summarized in appendix D, table II, will include:

a. Proficiency/FCLP flights at NAWCAD Pax River and the EFP. These proficiency flights, as summarized in appendix D, table II, will include day and night (unaided and aided) pilot proficiency/FCLP evolutions at the EFP (NAWCAD Lakehurst). The flights will include emergency procedures review (including degraded AFCS waveoff and recovery practice, which will be conducted using the "graceful AFCS degradation" buildup methodology described in paragraphs 42 and 43); EFP operations will also include procedures familiarization flights as a buildup for actual shipboard tests (discussed in paragraphs 44 through 47).

b. Proficiency/FCLP flights at the providing squadron (if possible) or other landbased facility. If possible, these day/night flights will be conducted to include a review of local field rules, non-NVD FCLPs, and emergency procedures review (including degraded AFCS waveoff and recovery practice, which will be conducted using the "graceful AFCS degradation" buildup methodology described in paragraphs 42 and 43). These flights will also be used to measure land-based aircraft performance characteristics (in accordance with paragraph 27) for later comparison with shipboard aircraft performance characteristics.

c. Deck Landing Qualifications (DLQs). Each pilot will meet appropriate DLQ requirements, (presented in appendix D, table IV) prior to the conduct of shipboard DI test operations. (Note that although all pilots flying in the aircraft during a DI test evolution must be a NAWCAD Pax River TPS graduate/Cat C qualified pilot, all test aircrewmen may be either fleet or Pax River personnel, provided that they meet NATOPS qualifications. All DLQ sequences will be conducted in accordance with existing NATOPS procedures. All night DLQs will be conducted by unaided pilots; NVD evolutions will NOT be conducted. If atmospheric conditions permit, the DI general launch/recovery envelope (appendix B, figure 12), aligned with the stern approach/lineup line, will be used for DLQ evolutions.

LANDBASED HOVER LADDER FLIGHT TESTS

23. As a desired part of the shipboard launch/recovery envelope development test effort, each test aircraft will attempt to conduct one or more day land-based "hover ladder" test sequences at the providing squadron or at some other land-based facility. These day tests, summarized in appendix D, table V, will be conducted to verify predicted gross weight/required torque values for the test aircraft, to quantify both in ground effect (IGE) and out of ground effect (OGE) hover performance characteristics, and to serve as a reference for shipboard hover torque values obtained during at-sea testing. As shown in appendix D, table II, one or more land-based hover ladder test evolutions will be conducted with the actual test aircraft. (Then, as described in paragraph 29, successive sets of shipboard hover ladder evolutions will also be conducted over the ship flight deck.) Both landbased and shipboard evolutions will be conducted with aircraft-relative wind speed and other conditions set in accordance with appendix D, table V. Both land and shipboard hover ladder test evolutions will consist of 10-20 sec duration IGE and OGE daylight hover sequences. As described in appendix D, table V, pilots will conduct each sequence under sequentially varying aircraft headings (within + 90 deg from the true wind), during which they will record the parameters specified in appendix B, figures 6 on flight data cards.

SHIPBOARD FLIGHT TESTS

GENERAL

24. Shipboard flight testing will be conducted in accordance with the established NAWCAD Pax River DI test procedures outlined below. The Shipboard Test Coordinator and/or Bridge engineer will request the Commanding Officer or the Officer-of-the-Deck to operate applicable ship systems to provide the wind-over-deck (WOD), ship motion (including operating ship rudders to create artificially increased ship motion, if desired/required), ship lighting, and/or other appropriate conditions required for each test sequence. After the ship has attained the desired conditions, one or more test evolutions will be conducted by the aircraft as necessary. During each flight test evolution, at least one NAWCAD Pax River Aircraft Project Engineer will have direct aircraft radio communication capability. Except for the approved variations specified in this

test plan (paragraphs 16 and 42-49), all shipboard sequences will employ NATOPS approach, recovery, and departure procedures.

SHIPBOARD HOVER LADDER FLIGHT TESTS

25. As part of the shipboard launch/recovery envelope development test effort, one or more day shipboard "hover ladder" test sequences will be conducted. These daylight tests will be conducted to compare gross weight and required torque values with NATOPS predictions, and with land-based values. Also, the test data will be used to quantify IGE, OGE, and single engine aircraft hover performance characteristics. (Note: NO single engine flights will be attempted during any at-sea testing; any single engine data resulting from this test will be based on dual engine extrapolations only.) As depicted in appendix D, table II, shipboard hover ladder test evolutions will be conducted over the deck prior to and/or in conjunction with, planned launch/recovery flight test operations. To provide the best comparison with land-based evolutions, the shipboard hover ladder evolutions will be conducted with WOD speed and ship motion stabilized to the greatest extent practicable Shipboard hover ladder evolutions will consist of 10-20 sec duration IGE and OGE daylight hover sequences, conducted under the conditions specified in appendix D, table V. As described in appendix D, table V, each sequence will be conducted under sequentially varying aircraft headings (within + 90 deg relative to the ship's bow), during which pilots will record the parameters specified in appendix B, figures 6 on flight data cards.

LAUNCH/RECOVERY FLIGHT TEST OPERATIONS

General

26. The day/night flight test methodologies discussed below were selected in order to maximize the amount and validity of test results for a variety of evaluations conducted within a limited time frame. In accordance with appendix D, table I and II, the majority of day and night test operations are scheduled to consist of multiple shipboard approach/recovery/launch/departure evolutions. However, as shown in appendix D, table II, various other component tests may also be conducted while underway, depending on ambient conditions. In accordance with appendix D, table I and II, during night operations, multiple shipboard approach/recovery/launch/ departure evolutions (NVD and non-NVD) will be conducted under NVD compatible blue lighting within envelopes developed during daylight conditions.

27. Pilots will conduct shipboard launch/recovery evolutions under day and night conditions, to limits dictated by pilot ratings or by ambient wind or sea state test conditions. Pilots will assign ratings of each approach/recovery/launch/departure evolution in accordance with guidelines set forth in the DI Pilot Rating Scale (PRS), Turbulence Rating Scale, Handling Qualities Rating Scale, and Vibration Rating Scale (which are presented in appendix C, scales I through IV, respectively) as applicable. Pilot ratings will reflect pilot workload and performance during shipboard launch/recovery tasks; Unacceptable pilot ratings are typically caused by degradation of flying qualities and/or performance in the shipboard environment.

28. Specific limitations that might be encountered during testing include insufficient flight control, torque, rotor speed, or power margins, excessive pilot workload, turbulence or ship motion, inadequate visual cues, or inadequate clearance distance between aircraft and ship structure. A summary of critical potential flight limitations (and minimum ratings that will be assigned to those evolutions, if reached) is presented in appendix D, table VII.

Day Operations

General

29. The major phase of shipboard testing will be conducted during daylight, under elevated sea state conditions as practicable. During this phase, the test team will attempt to produce a variety of wind and ship motion conditions by systematically varying the ship's course and speed for a given true wind/true wave direction condition, in turn facilitating investigation of the effects of previously unexplored relative wind speed and direction and/or ship motion magnitudes on a pilot's ability to conduct shipboard launch/recovery operations. After each systematic variation of relative wind speed and direction, pilots will conduct multiple repeated shipboard approach/recovery/launch/ departure sequences. In order to ensure a safe buildup for each specific (wind and motion) test condition, all day tests will adhere to the accepted DI buildup methodology outlined in paragraphs 34 through 41, as determined by test progression, test priority, atmospheric conditions, or other emergent requirements. These tests will include both bow and beam wind envelope explorations; after completion of the bow wind velocity buildup test procedures, the test team will investigate the effects of WOD direction variation on shipboard approach/recovery/launch/departure sequences. Both phases will be described in the following paragraphs.

Day Bow Wind Envelope Development

30. The initial WOD speed/direction that will be tested for each aircraft will be located within the day general DI launch/recovery envelope (aligned with the up-the-stern lineup line) presented in appendix B, figure 12). These initial WOD conditions will be chosen so as to minimize ship motion to the greatest extent possible for the given set of sea state and weather conditions. Under these conditions, pilots will conduct one or more stern approach/recovery/launch/ departure sequences. After completion of each desired approach/recovery/launch/ departure sequence, pilots will assign ratings and other applicable comments to the sequence, and radio them back to engineers aboard ship. For each ship course/speed (or equivalently, WOD speed/direction) combination selected, each aircraft will attempt at least one recovery/ launch sequence; pilots may also conduct additional recoveries, however, if warranted by emergent conditions.

31. After completion of all desired approach/recovery/launch/departure sequences attempted under a given set of ship course/speed conditions, the ship will be maneuvered to produce new relative WOD (and resultant ship motion) conditions for the next set of sequences. For each successive ship maneuver conducted during this initial phase of testing, the WOD speed will be progressively increased (at approximately constant relative direction, down the bow) in approximately 5 kt increments to the maximum attainable value, or until an unacceptable (PRS-3

or PRS-4) rating is assigned to an approach/recovery/launch/departure sequence. If a pilot assigns a PRS-3 to any sequence, the sequence may be repeated for verification only with pilot and test coordinator's concurrence. After verification of such PRS-3 sequences, subsequent bow wind approach/recovery/launch/departure sequences will only be conducted at relative WOD that are reduced in magnitude by at least 5 kt. If a pilot assigns a PRS-4 to any sequence, the relative WOD speed and ship motion will be reduced to levels corresponding to a previous PRS-2 or PRS-1 rating before attempting another sequence. Sequences conducted under conditions that produced PRS-4 ratings will not be repeated; any PRS-1, PRS-2, or PRS-3 sequence may be repeated as required/desired, with pilot and test coordinator concurrence.

Day Beam Wind Envelope Development

32. During this phase of testing, the ship will be maneuvered progressively so as to vary WOD direction to port or starboard in approximately 15 deg increments, while keeping the relative WOD speed constant, or at the maximum WOD speed attainable. Pilots will conduct one or more day approach/recovery/launch/departure sequences, using stern approach, for each ship course/speed combination selected.

33. After completion of each beam wind recovery sequence, pilots will radio PRS ratings and applicable comments back to the test engineers aboard ship. Again, if a pilot assigns a PRS-3 to any sequence, the sequence will be repeated for verification only with pilot and test coordinator's concurrence. If a verifiable PRS-3 is assigned to an approach/recovery/launch/ departure sequence conducted during this phase of testing, the relative WOD speed will be reduced in (approximately) a 5 kt increment (while maintaining a constant relative WOD direction) before conducting another sequence. If several verifiable PRS-3 ratings are assigned to successively lower WOD speed conditions along a given azimuth, sequences will be conducted at still lower WOD speeds, until a WOD speed condition producing a satisfactory PRS rating is attained. If a pilot assigns a PRS-4 to any sequence, the relative WOD speed, direction, and ship motion will be reduced to levels corresponding to a previous PRS-2 or PRS-1 rating before another sequence is attempted. Again, during this phase of testing, WOD/motion conditions that produced PRS-4 ratings will not be re-evaluated; any PRS-1, PRS-2, or PRS-3 sequence may be repeated as required/desired only with pilot and shipboard test coordinator concurrence.

Miscellaneous Day Envelope Development Test Procedures

34. For each aircraft, initial WOD conditions for each successive day shipboard flight test envelope development period will be located within previously tested envelope boundaries. Also, within the constraints allowed by ambient winds and previous test results, the initial WOD conditions on each successive test period will be chosen so as to provide both a rating verification check and to provide torque data for post-test nonstandard day performance estimation. (Basically, during the first test period for each aircraft, and at other times as required, the aircraft will refly one or more previously tested WOD conditions that corresponded to PRS-1 and/or PRS-2 ratings. These reflown points will thus be used to verify pilot ratings of tasks conducted in previous days, in an attempt to improve rating constancy and quality of data. Data from these points will then also be used to estimate aircraft performance for more extreme GW and/or

atmospheric conditions). Previously tested WOD conditions for each aircraft may also be retested to investigate the effects of aircraft loading, ship motion, or weather conditions, throughout the tests as required by each day's data analysis.

35. In general, pilots will relay comments and PRS ratings only after completion of each approach/recovery/launch/departure sequence; however, pilots may also elect to relay unsatisfactory (PRS-3 or PRS-4) approach/recovery PRS ratings while the aircraft is on deck, prior to launch. In this event, pilot and engineers will verbally confirm/establish the desired launch/departure WOD and/or resultant ship motion conditions (subject to all limiting PRS procedures discussed in this paragraph) before launch.

36. The procedures outlined in paragraphs 33 through 40 will be used to develop day shipboard operational launch/recovery wind and/or ship motion envelopes for each aircraft throughout the embarked test period. Testing will continue until the maximum safe day launch/recovery envelopes are developed, within constraints posed by available test time.

Degraded Flight Control Systems Recovery Tests

37. Testing to examine the effects of degraded AFCS parameters on CH-46E, and of degraded SCAS parameters on UH-1N shipboard recovery capability may be conducted during daylight test periods, if test time and/or ambient conditions permit, and if degraded AFCS recoveries were conducted during buildup evolutions at Pax River and/or the EFP. All shipboard day degraded AFCS recoveries will be conducted at WOD and ship motion conditions located within previously tested day nondegraded AFCS launch/recovery envelopes. No night degraded AFCS recoveries will intentionally be attempted.

38. Degraded AFCS testing will employ a "graceful degradation" buildup sequence, in which the effects of lesser degradations are investigated before proceeding to more severe ones. During initial degraded AFCS test recoveries, the pilot will artificially degrade the aircraft's flight control systems by selecting the appropriate degradation (AFCS RELEASE (SAS 1, SAS2, and AUTOPILOT OFF) for the CH-46E, and SCAS OFF for the UH-1N) prior to commencing an approach to the ship. Unless emergency recovery is required, the AFCS will remain disengaged for the duration of the approach/recovery task. After recovery to the flight deck, the AFCS will be reengaged prior to subsequent launch and climbout. This procedure may then be repeated, at pilot' s discretion, with a second and final system degradation (SAS/BOOST OFF for the CH-46E, and SCAS/BOOST OFF for the UH-1N) for another set of recoveries under the same WOD conditions. Each multiply-degraded AFCS mode recovery, however, will only be conducted for those WOD conditions previously tested as safe for single degraded mode AFCS recoveries. After completion of all desired degraded AFCS recoveries at a given WOD, the ship will be maneuvered, producing a different WOD condition, at which another set of degraded recoveries will be conducted. Degraded AFCS PRS ratings will be assigned using the same criteria as for nondegraded recoveries.

AERIAL PHOTOGRAPHY SEQUENCES

39. As discussed in paragraph 24, DI test engineers and test aircrew will document shipboard DI test evolutions with both video and still cameras. Provided test time, test priorities, and ambient conditions permit, the test aircrew will conduct aerial documentation of selected day/night test sequences. In accordance with appendix D, table II, during such aerial photographic sequences, the aircraft will conduct multiple approach/hover/waveoff evolutions (no full recovery photography evolutions will be conducted). All aerial photo documentation sequences will be conducted under previously tested WOD, ship motion, and deck lighting conditions; no aerial photo documentation sequences will be conducted during envelope development test operations.

Night Operations

General

40. Night launch/recovery test operations will be conducted under blue flight deck lighting. Night launch/recovery operations may include the evaluations listed in appendix D, table II, dependent on ambient conditions. Night launch/recovery test methods and procedures will be generally similar to day test methods and procedures, although self-imposed night shipboard flight test safety precautions will mandate some test procedural modifications. First, pilots will NOT be required to record test data on pilot data cards during night test operations (instead, either they or the aircrewmen will have portable tape recorders to record comments). Secondly, tape measure directional control (pedal position) instrumentation (described in paragraph 54) will NOT be used during any night operations. Finally, since these safety precautions will limit the amount of quantitative data obtained during night test operations, all night approach/recovery/launch/departure sequences will only be conducted under those WOD and ship motion conditions previously established as safe during day test operations. Thus, night flight test sequences will NOT be attempted under any WOD/ship motion conditions not contained within a tested day envelope. However, during night testing, each pilot will NOT necessarily be restricted to conducting test evolutions only under those WOD/ship motion conditions he personally evaluated in daylight. Additional safety precautions are summarized in paragraph 69.

Flight Deck Lighting Compatibility Evaluation

41. Current test plans call for pilots to conduct all shipboard and EFP night operations under NVD compatible blue flight deck lighting. (This is not required for the test; it is only desired.) When conditions are favorable for night shipboard flight testing, pilots will informally evaluate the adequacy of the blue lighting concurrently with test operations. When ambient conditions are too calm to allow the conduct of launch/recovery envelope expansion tests, pilots will conduct a night NVD and non-NVD lighting compatibility evaluation in accordance with the procedures described below. The test evolution summary provided in appendix D, table VIII will govern the conduct of this evaluation. As specified in the tables, during this evaluation, pilots will conduct multiple approach/recovery/takeoff/departure sequences, each under various combinations of flight deck lighting component intensity, and recovery type. During and after each evolution, pilots, aircrew,

Helicopter Control Officers (HCOs), LSEs, and other ship personnel will be asked to describe, critique, and comment on the visual compatibility (pilots will radio all comments while on deck).

42. During all lighting evaluation testing, the ship HCO will modulate the intensity of required shipboard VLA components prior to the commencement of an approach to the ship. The intensity of any modulated VLA system(s) will remain fixed throughout the duration of the approach/recovery/launch/departure task, unless otherwise directed by the pilots; modulated VLA components will be varied at any point in a test sequence if so requested by the pilot. For each sequence, pilots will assign PRS ratings the same as for a nondegraded landing. During each lighting test period, the ship will attempt to maintain a constant course and speed for as many consecutive evolutions as possible, thus minimizing adverse effects caused by variations in relative wind speed and direction. Lighting evaluation testing will immediately cease, at pilot/engineer discretion, if atmospheric conditions warrant.

SHIPBOARD NON-FLIGHT TESTS

SHIPBOARD COMPATIBILITY/AVIATION FACILITIES ADEQUACY EVALUATION

43. In accordance with appendix D, table IX, evaluation of the adequacy of ship aviation facilities, including the prototype flight deck lighting package and hangar/HCS/LSO station layout will be conducted concurrently with each of the test areas outlined above. In addition, the shipboard compatibility and adequacy of the test aircraft will be examined concurrently with the DI tests. Refueling is planned to occur approximately every two hours; although not specifically planned, underway periods will also include significant deck handling tasks, such as aircraft tiedown, aircraft traversing, and aircraft hangaring. Each such sequence that does occur will be qualitatively evaluated by pilots, flight deck crew, engineers, and shipboard observers, and documented by shipboard photographers, to assess UH-1N and CH-46E shipboard operational compatibility with RAST-equipped FFG 7 class ships.

INSTRUMENTATION

AIRCRAFT-MOUNTED INSTRUMENTATION

44. Dependent on operational test considerations, tape measure devices may be mounted to the directional control pedals to measure control excursions experienced during testing. Portable audio cassette tape recorder devices will also be employed to record pilot/aircrew comments via the aircraft Internal Communications System (ICS). Tape recorder and measuring tape mounting locations and procedures will be in accordance with standard USN Test Pilot School (USNTPS) practice. During aerial documentation sequences, aircrew will embark the aircraft with portable, hand-held video and still cameras; these will be connected into the aircraft ICS to record pilot comments directly onto the video. Other than the items mentioned here, no other test instrumentation will be mounted in the test aircraft.

SHIPBOARD INSTRUMENTATION

45. Test instrumentation and support equipment external to the aircraft is scheduled to include the following:

a. DI Audio Visual Instrumentation System (DAVIS), used to document flight test evolutions. DAVIS consists of two or more CCTV cameras hooked into a quad-split monitor, whose output is then mixed with engineer and aircrew radio comments (acquired by a portable scanner unit) and then fed into a VCR.

b. DI Ship Motion Package (SMP), used to document ship motion. The SMP, which includes COMPAQ 386 portable computer, ship motion instrumentation box, assorted cables, and SMP data collection/analysis software, possesses the capability to measure and record displacements, rates, and accelerations for ship roll, pitch, and yaw motions at 3 Hz. The SMP will also record ship course/speed and ship anemometer speed/direction inputs.

c. Portable camera equipment, (35mm still and VHS video) used by NAWCAD Pax River personnel aboard ship and inside the test aircraft to document test operations. Any photography conducted from within the aircraft may occur during launch/recovery evolutions, but will not occur during any untested wind/ship motion/ship lighting conditions.

d. Portable hand-held wind anemometers, used to document shipboard airwake/ airflow characteristics. During periods in which the aircraft is not flying, NAWCAD Pax River personnel will take wind speed/direction readings at various flight deck locations.

e. Portable walkie-talkie and cellular telephone units, used for shipboard test team internal/external communications.

f. Commercially available soap bubble solution (modified to improve bubble wall strength for high wind applications), used in conjunction with hand-held anemometers and video cameras to visualize and document flight deck airflow patterns during flight and non-flight operations.

g. Low light level NVD video and photometry equipment will be used to document night test operations and illumination levels.

h. Portable audiocassette tape recorder devices will be used aboard ship to record test team comments via the ICS during testing, and during post-test team debriefs.

SUPPORT REQUIREMENTS

GENERAL

46. The detachment OinC and shipboard test coordinator conducted prevail conferences aboard USS INGRAHAM on February 25, 1995. Detailed shipboard and aircraft support requirements are also addressed in the Operations Plan (reference (ff)), a preliminary version of

which will be presented to shipboard personnel prior to testing. Additional shipboard briefings, which will also review support requirements, will be conducted after initial shipboard arrival, prior to the conduct of flight operations.

47. Appendix D, table III provides a tentative shipboard test schedule. All test team members are scheduled to walk aboard ship while it is pierside. Test aircrews may embark/debark the ship while underway, via the test aircraft. After conclusion of NATOPS-requisite pilot/shipboard personnel briefings, NAWCAD Pax River pilots will conduct DLQs and test operations as called out in this test plan. The aircraft, aircrews, and civilian test team members are scheduled to remain aboard ship each underway night; all detachment personnel are tentatively scheduled to stay aboard ship for the duration of its underway period. Pilots/ aircrew may disembark the ship early, prior to port arrival. DI engineers are scheduled to walk off the ship after it returns to port. If tests are completed early, or if the ship's at-sea schedule changes, all test team members may fly to/from the ship while it is at sea, but only with appropriate permission from COMNAVAIRPAC.

FLEET SUPPORT

48. COMNAVSURFPAC (N42) will coordinated to provide requisite NVD training to the ship's crew to allow conduct of low level NVD operations.

49. USS INGRAHAM will host the embarked test detachment and will also provide primary SAR and refueling support. If required, USS INGRAHAM will also provide aircraft hangaring and maintenance facilities support.

50. Marine Light Attack Helicopter Squadron (HMLA), from MCAS Camp Pendleton, CA, will provide the embarked UH-1N test aircraft and maintenance/spares support.

51. Marine Medium Helicopter Squadron (HMM), from MCAS Tustin, CA, will provide the embarked CH-46E test aircraft and maintenance/spares support.

NAVAIRSYSCOM SUPPORT

52. NAVAIRSYSCOM has tasked and funded the conduct of this test. NAVAIRSYSCOM (PMA 251 and/or AIR 530) and NAWCAD Lakehurst will also coordinate with NAWCAD Pax River (RW40) to provide flight clearances and deck certifications to enable the conduct of shipboard flight tests.

NAWCAD LAKEHURST SUPPORT

53. NAWCAD Lakehurst will make available and operate the Elevated Fixed Platform available during day/night NVD/non-NVD launch/recovery practice evolutions prior to shipboard testing. If available, NAWCAD Lakehurst will coordinate with COMNAVSURFPAC to provide NVD compatible lighting filters and lamps.

NAWCAD PAX RIVER SUPPORT

54. NAWCAD Pax River will provide UH-1N and CH-46E test pilots (RW40 and RW60), aircrewmen (Dyncorp and RW60), DI flight test engineers (RW40), and all associated test support instrumentation and equipment.

55. In accordance with OPNAVINST 3750.6Q, NAWCAD Pax River MD will assume all incident reporting accountability/responsibility whenever NAWCAD Pax River pilots act as HAC in fleet aircraft.

56. NAWCAD Pax River (RW40) will coordinate to ensure that the NVD compatible light filters and lamps arrive safely at the test ship, and will install/remove all light filters and lamps for the test.

SPECIAL PRECAUTIONS

57. A NAWCAD Pax River safety checklist is included as appendix E to ensure that adequate safety precautions are followed. In addition, the following special precautions will be followed:

a. All project flights will be conducted with the minimum aircrew required for the safe and efficient conduct of operations.

b. Day and night (NVD and non-NVD) FCLP evolutions (either at the EFP or at NAWCAD Pax River) will be conducted to ensure pilot proficiency. FCLP operations will include day/night degraded AFCS recovery sequences as a buildup and prerequisite for shipboard test operations. Degraded mode AFCS waveoff and simulated engine failure waveoff procedures will also be practiced during FCLPs. The techniques employed during degraded mode AFCS practice and during shipboard degraded AFCS testing are identical, and are summarized in paragraphs 42 and 43.

c. After shipboard arrival of the aircraft, and prior to the start of actual tests, the test team will conduct a test procedural briefing with the flight deck crew. Topics of the brief will include aircrew rescue procedures for the event of flight deck crash or fire, aircraft tie down, power-up, refuel/defuel, and deck movement procedures. Review/summary of all shipboard air control procedures, deck status light/recovery signals, and VLA component names will also be conducted prior to flight operations.

d. Test objectives include night flights, without NVD, under ambient illumination levels providing less than 0.0022 lux; a summary of predicted operational area clear sky ambient illumination levels (determined using the USMC Light Level Planning Calendar computer program) is presented in appendix B, figure 15.

e. Night (unaided) degraded AFCS shipboard test operations will not be conducted (day degraded mode operations may be conducted, but are themselves a low priority.)

f. Each night test evolution will be conducted under WOD/ship motion conditions previously tested as safe during daylight. Deck lighting conditions employed during each night evolution will be adjusted according to a test matrix and/or to pilot preference.

g. A pilot will only conduct testing On any given night provided that he has previously completed both day and night DLQs.h. Pilots and aircrew will wear appropriate anti-exposure suits during both mandatory and "optional-wear" water/air temperature conditions.

MANAGEMENT

FUNDING REQUIREMENTS

58. Funding to cover DI test costs has been provided by PMA 251, under reference (g). These funds expire on 30 Sep 95. The cost estimate for this DI test is presented below in table I.

Table I
UH-1N, CH-46E/FFG 7 DI Test Costs

Effort/Item	Cost Center	Amount
DI Labor, Report Writing	(RWJO)	$ 55.0 K
Travel/Lodging/Per Diem Costs	(RWJO,RWDO)	$ 20.0 K
NAWCAD Prof Flight/Fuel Costs	(RWDO)	$ 30.0 K
Test Flight/Fuel Costs	(N/A)	$ 5.0 K
NAWCAD Lakehurst EFP Costs	(N/A)	$ 8.0 K
Material Costs/Photo/Misc.	(RWJO/AOPO)	$ 6.0 K
Report Printing Costs	(N/A)	$ 6.0 K
TOTAL DI TEST COSTS		$130.0 K

SCHEDULE/MILESTONES

59. A schedule/milestone chart is presented on the test plan cover.

PERSONNEL ASSIGNMENT

60. The NAWCAD Pax River DI test team members are listed in appendix D, table X.

PROJECT SECURITY

61. What is the overall security classification of the project?

Response: This is an UNCLASSIFIED project and test. The data requiring protection under this plan is sensitive rather than classified. Sensitive data is unclassified information that, when accumulated, may allow a Foreign Intelligence Service (FIS) to analyze it by compilation or mosaic methods to derive classified information. For this DI test program, sensitive data will not be transmitted via unencrypted (clear) telemetry data links and/or unencrypted voice communications.

A. Examples of sensitive data include the following:

1. System performance information and comments on the success or failure oftesting.
2. Technical performance specifications of the system and its performance capabilities.
3. Performance and evaluation of the system undergoing test and evaluation.
4. Formal test results indicating system limitations, deficiencies, and corrective actions.
5. Details of test methodology, including locations and dates and times of testing.

B. Examples of sensitive material include, but are not limited to, the following:

1. Technical Reports
2. Formal BIS and Yellow Sheet Reports
3. Formal briefings which contain the types of material listed above.
4. Information indicating performance of hardware listed in the H-60 series Security Classification Guides.

Sensitive data will be marked and handled as "FOR OFFICIAL USE ONLY" (FOUO) data, consistent with the guidance of SECNAVINST 5720.42D. At no time will FOUO information be exposed to unauthorized personnel. Dynamic Interface test sensitive data shall be stored in locked receptacles such as file cabinets, desks, or bookcases.

The FOUO marking will not be used on technical documents which require a distribution statement pursuant to DoD Directive 5230.24. Since no other means of protection is identified for protecting technical documents containing sensitive data, the documents must be handled and stored as described above.

This test, or portions thereof, will be conducted at a host facility or vessel that is not located on Patuxent River, Maryland, therefore the project engineer and test personnel will mark, control, transmit and/or publish all For Official Use Only information in accordance with NAVAIRTESTCEN Instruction 3070.3. All information regarding this test will be marked, processed, stored, and published and/or disseminated as required by appropriate DoN published policy and guidance.

All electrically recorded media, e.g., digital or analog tapes, photographs, charts, graphs, drawings, slides, and video tapes will be reviewed for security classification and marked in accordance with special instructions, security classification guidance, or at a minimum in accordance with OPNAVINST 5510.1H.

A definitive OPSEC annex to this test plan is not required and this action has been coordinated with RWATD OPSEC coordinator and approved. Host facility OPSEC procedures may be incorporated into this test plan.

REPORTS

POST FLIGHT REPORTS

62. Each pilot participating in a flight test period will complete and submit a post-flight report (daily) to the DI aircraft project engineer within 24 hours of completion of the test period.

PROJECT REPORTS

63. All post-test project reports will be co-authored by the project team. NAWCAD Pax River shall submit the following reports/briefs to the appropriate organizations:

a. A Message Report (MR), that summarizes the extent of testing and results, will start RW routing within 10 working days after the project engineering team returns from the test. Mr. Long will author the MR.

b. A Report of Test Results (RTR), that summarizes the extent of testing and results, will start RW routing within 20 working days after the project engineering team returns from the test. Mr. Long will author the UH-1N and CH-46E RTR.

c. A final Project Briefing, that summarizes the extent of testing and results, will be given within 20 working days after the project engineering team returns from the test. LT. Hood and Mr. Long will ensure that the briefing is conducted.

d. Yellow Sheets, supplemental final reports, and/or additional post-test briefings will be completed within applicable time periods as required/desired by the project sponsor. Mr. Long will ensure that all such post-test final reports or briefings are completed.

PROJECT DOCUMENTATION

64. As discussed in paragraphs 24 and 56, test aircrew and DI department members will provide day/night test photo coverage. The ship's flight deck video camera and UHF audio recording systems, supplemented by additional DI department video camera systems, will be used to monitor and record all flight test sequences.

ENVIRONMENTAL IMPACT

65. This proposed action is viewed as a continuous test and evaluation mission activity that poses no adverse threat to the environment; no substantial change is occurring to the continuing test and evaluation actions performed by FTEG. No significant environmental degradation or effect is known to be occurring as a result of these test procedures; therefore, this action is considered not significant and requires no further environmental documentation.